POLICY & PRIVILEGE IN PHOTOVOLTAICS: A COMMUNITY LEVEL ANALYSIS IN SAN DIEGO COUNTY

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ABSTRACT

Policy & Privilege in Photovoltaics:
A Community Level Analysis in San Diego County

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This research investigates the demographic and local government permit characteristics of communities with high levels of solar adoption in the San Diego Region. Utilizing a statistical model, this research illustrates which communities have been able to benefit from the current solar incentive programs in a robust market with an abundant solar resource. In San Diego, zip codes with large proportions of people over 65 have the highest correlation with high levels of residential solar adoption. This potentially illustrates that the life changes associated with retiring, including accumulated wealth, stable homeownership, and a fixed income, make residential solar systems accessible and appealing. Moving forward solar policy should expand to better facilitate installations for renters, sharing between neighbors, and clear pathways to retrofit older homes.

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LIST OF ACRONYMS

ACS – American Community Survey

CAP – Climate Action Plan

CEC – California Energy Commission

CSI – California Solar Initiative

GHG – greenhouse gas

IOU – Investor Owned Utilities

kWh – kilowatt hour

MASH – Multifamily Affordable Solar Housing

NEM – net energy metering

OAT – otherwise applicable tariff

PG&E – Pacific Gas & Electric

PPA – power purchase agreement

PV – photovoltaic

RPS – renewable portfolio standard

SASH – Single-family Affordable Solar Homes

SCE – Southern California Edison

SDG&E – San Diego Gas & Electric

TOU – Time of Use

VNM – virtual net metering

ZNE – zero net energy

GLOSSARY

CSI – California Solar Initiative: The CSI was an incentive program administered by the State of California, which provided rebates for disaggregated solar systems between 2007 and 2015. The goal of the CSI was to provide incentives that lowered the price of panels to a market competitive rate while the technology improved and became less expensive. The CSI database is the source of data for this research.

Grid-tied: Grid-tied solar systems feed excess energy back onto the grid and do not have battery storage. Grid-tied systems to not function during a blackout.

IOU – Investor Owned Utilities: Investor owned utilities are private for-profit companies that provide utility services. They are highly regulated by government because they provide a public service. Regulation focuses on clean energy procurement and fair energy pricing, especially for low-income households. The three IOUs in California are Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E)

NEM – Net Energy Metering: NEM is a process where the excess energy from a solar system is sold back on the grid. Under NEM contracts, customers pay for the energy they buy from the grid, less the wholesale value of the energy their system adds to the grid over a 12-month period. NEM is colloquially referred to as running the meter backward.

PV – Photovoltaic: PV systems use semiconductors to convert solar energy into current electricity for utility use. These are the dark blue solar panels.

Background

Introduction

Residential solar systems are often a symbol of altruistic environmentalism for the good of humankind; however, in addition to altruism, these systems also may have private financial benefits. State rebates and local permitting practices affect who adopts and therefore, receive those benefits. Research has shown that wealthy, white, and liberal communities are the most likely to install solar panels – but San Diego appears be breaking some of these trends. San Diego is the second largest solar market with rural, urban, wealthy, and low-income adopters. This makes San Diego the ideal landscape to study the effectiveness and bias of residential solar policy across a diverse set of communities.

This research investigates which communities in San Diego have high adoption rates to determine the housing types and demographic characteristics that benefit from the public utility rules and local permitting processes. The results illustrate where extensive rebates and pro-solar policy miss populations. Other jurisdictions and state legislators can build on this research to design programs that help facilitate PV adoption in underrepresented communities.

Purpose

Residential solar systems both serve to reduce greenhouse gas emissions and adapt to increasingly hotter summer months as a result of climate change by reducing energy costs during these peak times. Most of the energy urban residents use is generated by utility scale power plants distant from the communities where it is used. This centralized model is inefficient and non-adaptive. Power plants are built to meet peek seasonal and daily demands – nationwide this load is met approximately 1% of the time (Blumsack & Fernandez, 2012). Furthermore, when energy demand increases above normal capacity blackouts can occur. To curb demand, peak pricing raises energy costs to discourage non-essential uses (SDG&E, 2015b). These price surges can disproportionately affect low-income households and those who depend on energy for life support equipment or medication.

There have been numerous Federal and State programs, such as the Go Solar California (2015c), that have been deployed over the past decade to help incentivize and usher in residential rooftop photovoltaics (PV). The financing options and regulatory structure of these programs makes residential solar more accessible to certain, ostensibly white homeowner, communities. As solar moves forward, becomes less expensive, and energy pricing changes because of it, planners ought to understand who has benefited from past programs and why, so they can better serve a more diverse population moving forward.

There is no centralized database for PV installations nationwide or in California and little analysis has been completed ranking metropolitan areas by solar friendly policies. Solar industry reports rank the City of San Diego second in the nation in total PV installation after Los Angeles and 4th in per-capita installation (Burr & Hallock, 2015). Given San Diego's success, it is an important case study on the distribution of PV installation and the associated benefits. Residential solar installations reduce a household's dependence on the energy grid, by generating energy for the house to use and sell back to the power provider under current net-metering rules. This can both reduce energy costs and stabilize the price of energy against fluctuations in the energy market, including demand-pricing spikes during extreme heat days (Center for Sustainable Energy, 2015).

National scale research focused on the demographic patterns of residential solar installations illustrate that jurisdictions with higher median income, a higher proportion of white residents, and more registered Democrats, also have a higher level of residential solar adoption (Graziano & Gillingham, 2014; Kwan, 2012). Research based in California demonstrates that more affluent households, who also use more energy are more likely to adopt solar (Bornstein & Notsund, 2014).

The current rate structuring charges high energy users, usually associated with large homes in suburban areas, higher rates per kilowatt-hour (kWh). This price structure is meant to curb high levels of energy use, consequently also makes the solar offsetting most profitable for these users, because it not only reduces total energy, but the price per kWh of the energy is purchased. Net-metering policies, better known as 'running the meter backward,' is a mechanism where the unity buys excess solar energy at a wholesale rate, much lower than the rate a residential user purchases it. Since the incentive benefit is in reducing energy, not selling it, low energy users who are charged less per kWh from the utility and would sell a greater amount at the low wholesale rate face a smaller financial incentive. Furthermore, most residential solar systems require large initial investments and home ownership. Together, these compound the benefit to wealthy suburban customers.

Another growing body of research links reduced costs and permit processing times to increase PV adoption rates (Brown &Chandler, 2008; Burkhardt et al, 2015; Complete Solar, 2014; Dong & Wiser, 2013; Li & Yi, 2014). Confusing, costly, and time consuming permit applications can disincentivize residents who find bureaucratic processes prohibitive. High permit costs and the time a solar contractor spends preparing documentation has a direct effect on system costs. The real, or even perceived, difficulty of processing the necessary permits can dissuade a consumer from purchasing solar panels.

The purpose of this research is to understand how these social and legal variables interact within the San Diego solar market and compile the demographic and policy characteristics of high adoption communities. The research aims to uncover the typology of communities with high PV adoption rates. Statistical analysis uncovers which populations have best utilized the State funded PV adoption programs and which policy variables are the most effective in influencing PV adoption. By uncovering patters in San Diego, this research highlights who benefits in a large scale and developing solar market – and which populations policy is missing.

Three categories of explanatory variables are investigated to explain high per-capita PV adoption rates: housing, demographics, and local permitting. Housing density and ownership can predetermine likelihood and even eligibility for enrollment in State rebate programs. Demographics, specifically income, affect the financing options for procuring systems. Lastly, local processes can simplify and lower the cost of installing systems, broadening the opportunity to those who are dissuaded by complex bureaucratic processes. These three variables do not act independently and, when combined, illustrate who is being served by the current incentive structure. Since San Diego is a robust and diverse solar market, the communities that are under-represented identify where future policy ought to be addressed next.

The Role of Planners

All solar systems require a permit from the local government. These permits require engineering illustrations, planning blueprints, and often multiple visits to the city or county offices. Planning permits generally fall into two camps: allowed (or by right) uses and discretionary. If an action, such as installing a PV system is an allowed use, the requirements – such as maximum building height or necessary equipment diagram – are published and available to the public. If the applicant wishing to install a PV system follows all of the predetermined rules, the permit is approved (see Appendix A). Conversely, a discretionary permit is not automatically approved, and requires the review and professional opinion of the development or planning director. Discretionary permits are generally understood to be less straight forward, but both can have arduous application packages with multiple engineering drawings, site plans, trips to planning department, and application fees. If these hurdles are reduced, the cost and difficulty of installing solar are also decreased.

Planners and policy makers who regulate and administer permits for residential solar installations can unwittingly impose a ‘confusion factor,’ if there is not a consistent and transparent process (Brown & Chandler, 2008; Carley, 2009). While most utility policies and distributed generation goals are decided at a State level, implementation is carried out by local governments (Li & Yi, 2014). Planners, implementing local policy, affect the amount of time and money it takes for an applicant to have their solar system approved and installed. Streamlined permitting processes can shorten the time it takes applicants to get approval by 25% (Dong & Wiser, 2013).

The regulatory process also may have a substantial cost impact. In 2012, 64% of the costs to install solar were ‘soft costs’, or those costs not associated with hardware, such as a building permit (Friedman et al., 2013). These soft costs are not consistent between jurisdictions. Research has found that permitting costs can lead to a cost differential of $700 on an average sized system from the least to most favorable jurisdictions, when all regulatory costs are considered the saving jump to $2,500 (Burkhardt et al., 2015).

Recent California law mandates that all communities utilize best permitting practices, such as streamlined permitting. AB 2188 requires that each city and county adopt an ordinance that streamlines the permit process for small residential rooftop solar systems. Each permitting, jurisdictional ordinance must update their permit process to meet the standards in the most current version of the California Solar Permitting Guidebook. The major changes required by AB 2188 include: an online permitting process, a single inspection process, and a published checklist of all the standards. Ordinances under AB 2188 had to be adopted by September 30th 2015. The analysis in this research predates these legal changes.

San Diego County, California

San Diego County is the most southwesterly county in the continental United States. San Diego County is home to 19 jurisdictions, including both the City and County of San Diego. The City is the second most populous in the State behind Los Angeles. The San Diego region is also home to multiple military bases, five universities, multiple native American tribes, rural communities, suburban tracts, and urban centers. The San Diego region is perhaps best known for its sunny weather, which not surprisingly make it a hot bed for residential solar installations.

The San Diego region is home to over 3.18 million people. Less-than-half (45.6%) of San Diegan's identity as white non-Hispanic to the U.S. Census Bureau, and just under a third (32.7%) of San Diegan's identity as Hispanic or Latino of any race. The median household income in the County is almost $64,000 annually and 31% of the population are categorized as poor or struggling. Slightly more than half of the households in the San Diego Region (53%) own their own home. The majority of people (57.6%) live in either the City of the County of San Diego.

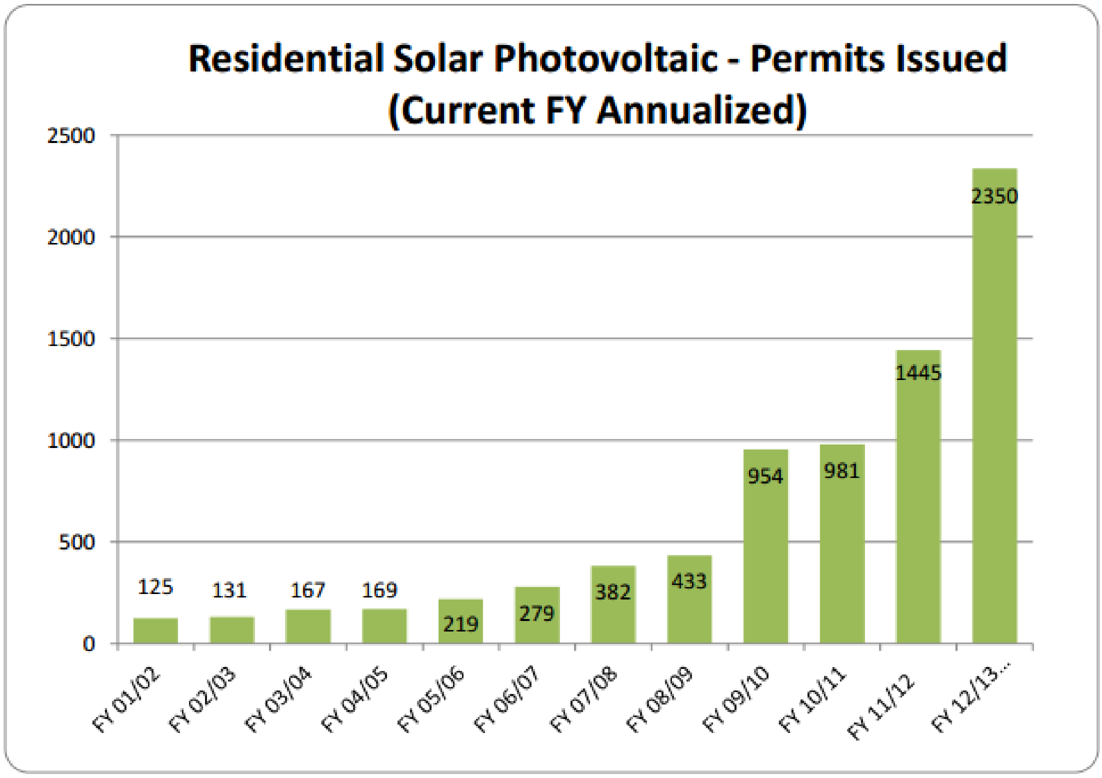
The City of San Diego

The City of San Diego is made up of more than 40 urban and suburban communities (City of San Diego, 2016). The City adopted a climate action plan (CAP) in December 2015 after the California Solar Initiative (CSI) funds were fully distributed. According to the CAP, the San Diego metro area experienced the second fastest growth in distributed solar installations through the CSI between 2012 and 2013, and had a total of 136 MW installed during the life of the program. San Diego ranked seventh in clean tech job activity nationwide in 2010. The CAP sets a goal of achieving 100% renewable energy by 2035 (City of San Diego, 2015).

The County of San Diego

In 2013 the County of San Diego published the 2013-2015 Strategic Energy Plan, which included an accounting of renewable energy through the 2012-2013 fiscal year. Through 2012, the County permitted over 45 MW of renewable energy, 19.25 MW of which were residential PV installations. In 2010, the County Board of Supervisors amended the zoning code to allow for height and setback expectations for PV systems and included a non-discretionary permitting process for PV facilities smaller than 10 acres (see Appendix B). After the 2009/10 fiscal year, there was an 137% increase in PV permits (see Figure 1) (County of San Diego, 2013). The County only issues PV permits at one central office in Kearny Mesa, but has had tremendous success with an online processing system. The County of San Diego is re-writing their CAP after a court challenge with a completion slated for fall 2017 (County of San Diego, 2016).

Figure 1: PV Permits Issued San Diego County



Source: County of San Diego, 2013

Financing and Benefit Structures

Between 2007 and 2015 the State of California provided incentive rebates for residential solar installation. These rebates were part of a 2.3-million-dollar initiative to increase distributed PV around the state. The initiative also established the largest database of residential solar installations and approved contractors in California. The contractors are approved by the State of California to install personal PV systems and work with the California Energy Commission to receive the applicable solar rebates. Typically, installers apply for both local permits and State incentive monies based on their professional expertise (Go Solar California, 2015e). These contractors fall into two major categories: host and third party owned. A host owned project can be defined as when the same person owns the roof and panels, where as a third party owns the panels and sells the energy back to the roof owner or their tenants under either a power purchase agreement (PPA) or lease agreement (both described below).

Solar Contractors and Third Party Installers in San Diego County

The California Energy Commission (CEC) maintains a searchable database of solar contractors that reflects the proportions of host-owned and third party systems across the state. Of projects installed with CSI funds is an approximate ratio of 2:1 homeowner to third party owned projects in San Diego County. Almost three quarters of qualified contractors in San Diego only install host-owned systems, while the third party market was dominated by a handful of large companies (Go Solar California, 2015b). Of third-party contractors, Solar City installed almost 22% of total third-party systems in San Diego County.

Third party leasing opportunities through these companies were dominated by six contractors who together account approximately 57% of all third party installations. The purpose of State incentives was to offset the high initial costs of buying solar systems. As a result, the CSI database may undervalue the proliferation of third-party systems due to the flow of incentives and reduced capital cost of systems (Housman, 2015). California as a whole tends to favor third-party, in almost reverse ratios to the CSI projects in San Diego. As of February 2015, more than 60% of homeowners installing solar in the state opted for third-party ownership (Housman, 2015). The opposing ratios likely mean that San Diegan's are more often supplying upfront capital than the state as a whole.

For the 34% of San Diegan solar residents utilizing third-party installers, there is a considerable price reduction. The average owner-owned installation costs $6.54 per watt, while the average third-party installation only costs $1.74. Third-party installers expand the market for residential PV adoption because they remove the need for upfront capital and restructure benefits from long-term cost-recovery to a lower energy bill the first month after installation (Drury et al., 2012). In simpler terms, because a third party owner requires little or no upfront cost and can offer immediate savings on one's monthly energy bill, they expand the PV market to households who previously could not afford it. There are three major financing options when pursuing residential solar. Third-party adopters can choose to lease or PPA, while homeowners can pursue private loans. Regardless of the financing structure, households still pay for any excess energy needs beyond what the panels can provide - most notably night usage in the absence of advanced battery technology (U.S. EPA, 2015).

Residential Solar Financing Options

There are three major financing options for households installing solar systems: leases, PPA, and direct purchase. Some financing options require minimal upfront capital and/or more consistent financial benefits. These differences can attract less-affluent households to adopt solar. In the case of San Diego, households east of the City generally have a smaller median income and are classified by SDG&E as being in more energy intensive climatic zones (SDG&E, 2015c). A greater variety of financing options can encourage such households in high solar areas to adopt residential PV systems and expand those who benefit from these systems beyond those high-income suburban households who have been found to typically adopt. A full explanation of the differences between the three financial structures is illustrated in Table 1.

Leases

Under a lease agreement, a homeowner enters a contract to pay pre-determined payments to a solar company who installs, owns, and operates the solar system on their property. These pre-determined payments, allow the household to install solar without needing upfront capital. Households who lease their panels receive all the power from their panels as well as any payments from the utility for excess energy put back onto the grid. While the lease payments to the solar installer are fixed, energy prices to the utility are not. In these arrangements, the household depends on their energy bill savings to be more than their payment on their lease. These arrangements are attractive due to their simplicity (Hausman, 2015).

Power Purchase Agreements (PPA)

Under solar PPA contracts, the solar installer installs, owns, and operates the system, but the homeowner buys power at a predetermined per-kilowatt-hour basis. These rates are competitive with the utility market. Since the homeowner knows how much the electricity will cost throughout the system, they are insulated from a possible increase in local utility rates (Hausman, 2015). PPA agreements also include system maintenance, unavailable in lease and outright purchase of panels.

Owning Solar

Homeowners who have access to capital and/or private loans may opt to purchase panels outright. This transaction functions as a simple home improvement. The homeowner upgrades their house by purchasing solar, and receives free energy when using their system as well as any applicable payments from their utility company when excess energy flows back onto the grid. The homeowner is responsible for maintenance of the system and may need to purchase additional or expanded insurance to cover their panels. This remains one of the most popular options, but limits some households with fewer financial resources for purchasing solar systems.

Table 1: Comparing Residential Solar Financing Options

	Solar Leases	PPAs	Direct Purchase
Who buys the system?	Third-party developer	Third-party developer	Homeowner
Who owns the system?	Third-party developer	Third-party developer	Homeowner
Who takes advantage of most of the federal and state incentives available for solar?	Third-party developer	Third-party developer	Homeowner
Who is responsible for operations and maintenance of the solar system?	Usually the third-party developer	Third-party developer	Homeowner
Who incurs the risk of damage or destruction?	Third-party developer	Third-party developer	Homeowner

Table 1 (cont'd): Comparing Residential Solar Financing Options

	Solar Leases	PPAs	Direct Purchase
What happens if the homeowner sells the home where the solar system is located?	Depends on the contract	Depends on the contract	If the homeowner finances the system through a loan, the homeowner remains responsible for the loan payments after the transfer unless negotiated with the buyer.
Are financing payments fixed?	Yes, payments are pre-set, but may include an annual escalator, increasing payments each year.	No. Payments to the third-party are on a per kWh basis based on electricity generated. Payments may include an annual escalator.	If the homeowner finances the system through a loan, the loan payments will be fixed. If the homeowner decides to purchase a system outright, a contractor may sometimes offer several payment installments instead of one lump sum.
What contract duration terms are available?	Terms can vary	Terms can vary, but are often in the range of about 20 years.	If the homeowner finances the system through a loan, the loan terms can vary.
Do contracts provide minimum production guarantees?	Yes, usually. Solar lease providers commonly provide minimum production guarantees.	Yes, usually. PPA providers often provide minimum production guarantees.	A loan contract does not include production guarantees. However, a solar panel manufacturer or developer/ installer may provide a production guarantee.
Are there escalator clauses in the contracts?	Sometimes. Check the contract for specific terms.	Sometimes. Check the contract for specific terms.	If the homeowner finances the system through a loan, interest rates may increase over time depending upon the specific terms of the loan.
Is insurance coverage provided?	Yes	Yes	No, homeowners may need to purchase new or expanded coverage.

Adapted from: Hausman, 2015

Regulatory Framework

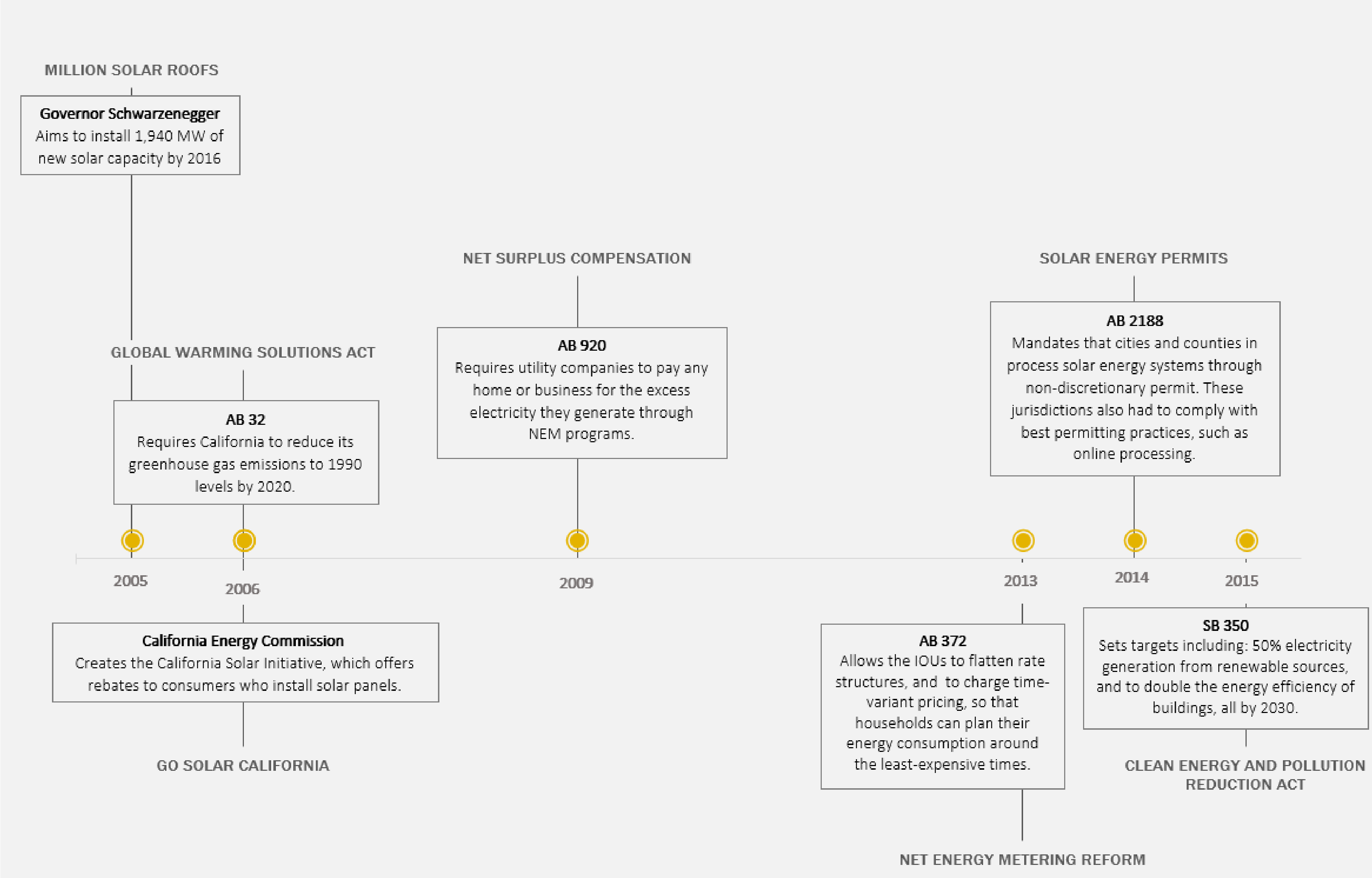
State policy sets the framework under which all energy procurement is developed. In 2005, Governor Schwarzenegger signed AB-32 the California Global Warming Solutions Act. AB-32 set forth policies to reduce California's emission of greenhouse gases (GHG) to 1990 levels by 2020. This would represent a 15 percent reduction in GHG by 2020 (CARB, 2014). This goal was recently extended to 40% below 1990 levels by 2030 through Executive Order B-30-15, formalized into law by SB 350. A timeline of the relevant legislation is illustrated in Figure 2.

Renewable Portfolio Standard

The implementation of AB 32 spurred the development of new and modified State law to establish comprehensive, measurable climate change policy in the state. A large piece of this policy overhaul was the modification of the renewable portfolio standard (RPS). The RPS was established in 2002 and has been continually strengthened through a series of legislative actions. The RPS sets renewable procurement standards for investor owned utilities, electric service providers, and community choice aggregates (CPUC, 2015b). SB 350, signed by Governor Brown in 2015, extends the targets of the RPS to 50% renewable procurement by 2030 from 33% by 2020.

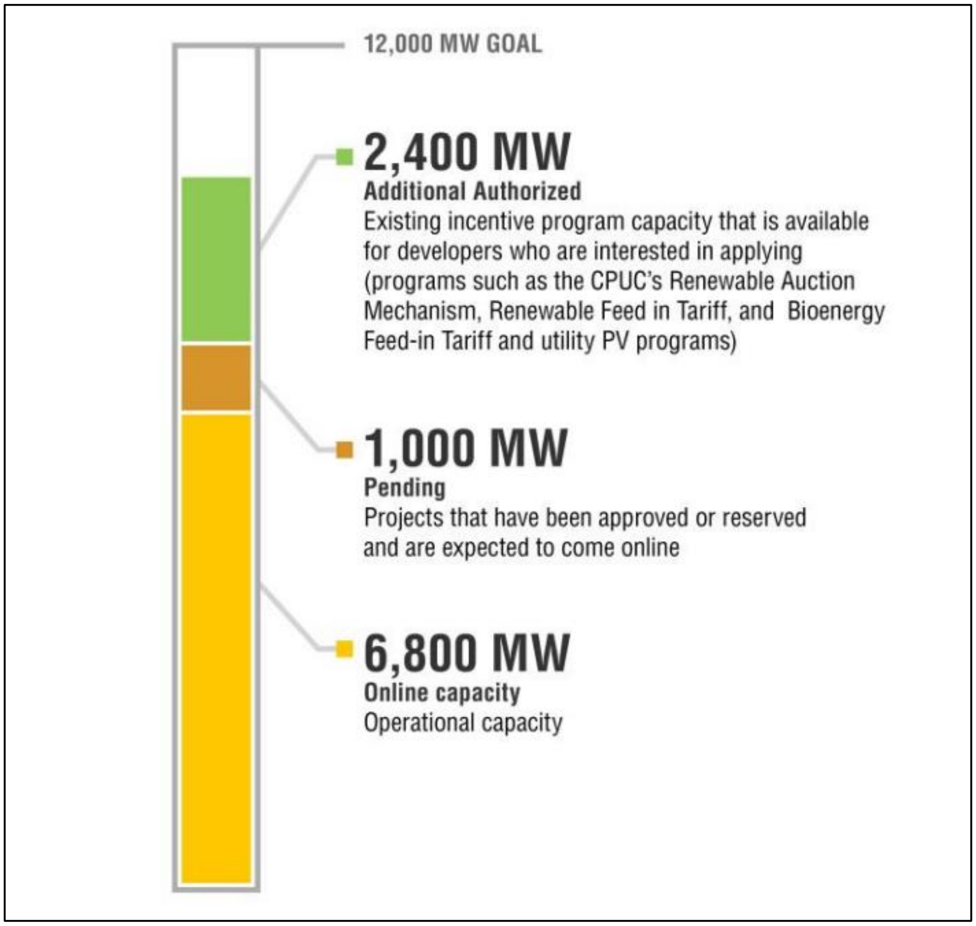
Currently, distributed generation is not covered by the RPS. Instead, it is implemented through incentive programs under the goals of AB 32 and its associated Executive Order amendments. Governor Jerry Brown set forth a goal of installing 12,000 MW of distributed generation by 2020. As of June 30th, 2015, 6,800 MW have been installed, and another 1,000 MW is currently pending. Successful incentive systems, including the California Solar Initiative, have exhausted their funding, but remaining programs could add another 2,400 MW with the remaining 1,800 possibly being achieved through market forces as PV energy becomes less expensive (see Figure 3) (CEC, 2015).

Figure 2: Legislative Timeline



Adapted from: California-Solar.Org, 2013

Figure 3: Renewable Distributed Generation in California



20 MW or Smaller, Includes Wholesale and Self-Generation
Source: CEC, 2015

Incentive Structures

The State provides rebates and financial incentives to make solar systems competitive in the market. Various rebate and incentive programs serve specific populations and interact with a changing framework of energy pricing. State programs and energy pricing schemes can provide more savings to high energy consuming, single family homes and, because of this, explain some of the characteristics in high adoption communities across the study area.

California Solar Initiative (CSI)

The California Solar Initiative was launched in 2007, the product of legislative action and an integral part of Governor Schwarzenegger's 'Million Solar Roofs' Vision. The CSI had a project budget of 2.367 million dollars to be spent by the end 2016. There are five main components of the initiative, each with its own project budget: (1) CSI General Market program; (2) Research Deployment and Development (RD&D); (3) Single-family Affordable Solar Homes (SASH); (4) Multifamily Affordable Solar Housing (MASH); and (5) CSI thermal program.

All components are available only to customers of the State's three Investor Owned Utilities (IOUs); Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric SDG&E (Go Solar California, 2016a). Three of these programs: General Market, MASH, and SASH, provide finical incentives for residential solar systems, and only apply to grid tied systems which will allow energy to flow back onto the IOU's grid, not stored in battery systems or used to power backup generators (SDG&E, 2015b).

The General Market program, commonly known as 'Go Solar California' is the primary incentive component of the CSI. Go Solar California distributed an initial budget of 1.95 million dollars to utility customers. The amount of money given to each household under Go Solar California started relatively high and ratcheted down as solar systems became less expensive. The purpose of this decreasing incentive was to pace solar development and market driven decreasing costs so that the incentive could artificially maintain competitive solar pricing as technology improved and became less expensive.

The incentive money was to be distributed in 10 steps or phases between 2007 and 2017. Each step had a predetermined payback to participants and target capacity. Incentives were available in either upfront per watt installed or monthly payback per kWh used, both predetermined by the program step at the time of purchase. The target capacity was a MW allowance for each step, once that many MW were developed, the incentive moved to the next step and the paybacks were reduced, creating a demand driven solar market (see table 2) (CPUC, 2015a).

Table 2: CSI Step Program

Step	Statewide MW in Step	EPBB[1] Payments per Watt	PBI Payments[2] per kWh
1	50	n/a	n/a
2	70	$2.50	$0.39
3	100	$2.20	$0.34
4	130	$1.90	$0.26
5	160	$1.55	$0.22
6	190	$1.10	$0.15
7	215	$0.65	$0.09
8	250	$0.35	$.15 (a)/ $.139
9	385	$0.25	$.12 (a) / $.114
10	350	$0.20	$0.09

[1]EPBB (Expected Performance Based Buydown): The applicant receives the entire incentive payment at the time the system is installed, and the payment is based on expected electrical output of the system.
[2]PBI (Performance Based Incentive): The applicant receives a portion of the incentive payment every month over a period of five years, and the payment is based on the actual metered output of the system.
Adapted from: Go Solar California, 2015d; 2015f

Of the four supplemental CSI Programs, SASH and MASH both support the adoption of residential systems. Both programs are included in this research, but only account for 3.5% of installations cataloged by the California Energy Commission. The SASH offered a larger incentive of $3 per watt to households whose income is less than 80% of the area median income, significantly more than even the earliest general CSI incentives shown in Table 2 (Go Solar California, 2016b). MASH offered a variable incentive to affordable housing developments; larger incentives were available to projects that offset a greater proportion of tenant load as opposed to the common areas. Both SASH and MASH were considerably smaller programs, which is reflected in the CSI data for San Diego County utilized in this research.

Net Energy Metering (NEM)

Solar systems are often attractive to install due to their potential to "run the meter backwards". During peak solar hours and/or low energy consumption time periods, solar systems produce more energy than is needed on the site. This energy is then put back onto the grid and purchase by the utility at a wholesale rate in a process known as NEM (Borenstein & Notsund, 2014; CPUC, 2015c). This is appealing to solar-owners due lacking battery technology allowing them to store energy until it is in demand. If the utility purchases the energy, it is often processed as a bill credit that offset customer's utility bill.

NEM policies allow customers to install smaller, and therefore, less expensive systems that meet annual loads instead of peak demands. This flow of energy also buffers against the obvious seasonal differences in solar energy generation. Systems can offset energy demand during the summer months, even dampen increasing demand of air conditioning during more frequent heatwaves as a result of climate change. At the same time, households purchasing solar systems do not need to invest in systems (arrays or batteries) to meet the total demand of the house, therefore decreasing the total initial capital investment.

California NEM Policy through 2016

As of March 2015, more than 90% of grid-tied systems in the three large investor-owned utility territories were enrolled in NEM tariff programs (CPUC, 2015c). Under the current NEM policy, there is an annual accounting process by the IOUs. If the household is a net consumer over the year, they owe the utility for the energy used above that produced on their roof. As of 2011, if the household is a net producer, they are compensated based on the average day-ahead wholesale price between 9am and 5pm. Roughly 5% of households statewide are PV net exporters. Even though the majority of households are not net exporters annually, more than a third of the energy flows back into the grid (Bornstein & Notsund, 2014).

Importance of NEM

The energy delivered by NEM generators provides local energy to households without solar installations (CPUC, 2013a). This helps slow the pace of energy demand as communities grow or utilize more energy – especially daytime use of air conditioners. While distributed solar (including residential rooftop solar using NEM) is not currently included in the State RPS standards, the energy produced by NEM generators can reduce the pressure on the utility to build utility plants regardless of energy source, decreasing cost to rate-payers in the form of avoiding the cost of new plant land procurement and new distribution infrastructure costs.

Research has found that NEM policies do reduce initial barriers into the market and dramatically increase the rate of return of the system making them more attractive (Krasco, 2013). While there is little research on the role of NEM in solar adoption rates, NEM does make systems more attractive to homeowners and investors, and off-set the intermittency costs – or money that the solar customer spends on energy when the sun is not shining.

Critiques of NEM and Restructuring Efforts

Critiques of NEM argue that customers with solar systems are not paying their fair share of utility services such as communal transmission line maintenance, because those participants that “zero out” their bill do not pay for their share of the utility infrastructure that they use to sell back and distribute energy. These costs are directly shifted on to the utility, and therefore, on to the non-solar utility customers. These potentially free services include maintenance of the grid, integration costs, customer service, and other administrative costs. (CPUC, 2013; IREC, 2013).

The grid is a quasi-public service. The grid is privately owned and operated, but provides an obvious public good. California’s IOUs are highly regulated to provide affordable, reliable, and now increasingly clean energy to a majority of California residents. This dynamic effects NEM reform by inserting both profit and public motives intro legislative remedies. NEM reform must balance the system wide cost of energy development and utility infrastructure cost. While most households utilizing NEM programs are not net-exporters and therefor do not utilize grid-services for free, the IOUs and legislator felt that there was not a uniform and fair system to account for the proliferation of small scale energy procurement, which required revisions to the public utilities code.

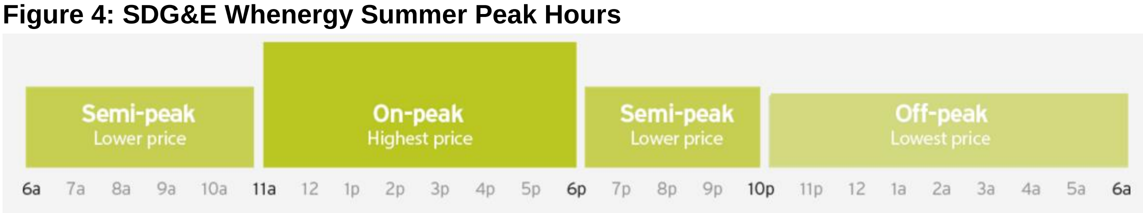
Current NEM policy sets rates that the utility must pay until a predetermined amount of energy (or cap) is met. Once the cap is met, the utility does not need to accept new NEM customers. The cap was most recently updated in 2010, raising the cap to 5% of aggregate peak demand. Aggregate peak demand is defined by a four-year average of the annual highest demand over 15 minutes (SDG&E, nd). For SDG&E that is 617 MW total (CPUC, 2015c; SDG&E, 2015e). Recent legislation (AB 327) amends the cap, and allows the IOUs to stop offering current

NEM rates after July 1st, 2017 (Hilton & Marriott, 2013). Those included in the program receive NEM rates for 20 years after their installation date, so customers that install between AB 327 being passed and the cutoff date are considered grandfathered in (Cenergy Power, 2013). These changes have prompted solar companies to advertise a sense of urgency to potential customers.

AB 327 sets the framework for NEM reform. First, it allows up to a $10 monthly fee fixed charge for residential rate payers, flattens utility rates, and allows for time-of-use (TOU) pricing. The monthly fee would pay for use of the grid regardless of how much energy the household purchases (or sells) to the grid (CAL SEIA, nd; Churchill, 2015). The flatted utility rates would un-do tiered pricing and charge more equal rates between ratepayers (see Table 3).

TOU would change the price of energy throughout the day based on demand. SDG&E playfully refers to TOU pricing as ‘whenergy’. In California, the highest demand – and now highest price for energy – is summer afternoons when many households need to utilize their air conditioning (See Figure 4). TOU pricing would encourage people to use non-essential items such as laundry or charging an electric vehicle for off peak times (CAL SEIA, nd). An increase in residential PV systems would also increase supply during summer daytime hours. This would decrease demand and therefor energy prices during the daylight hours. Implementing AB 327 is left to the utilities.

Figure 4: SDG&E Whenergy Summer Peak Hours



Source: SDG&E, 2016

SDG&E has proposed a new NEM 2.0 program to replace the current rate structures. This program would have two options: default unbundled rate and sun credits. In a default unbundled rate option, a customer-generator (a.k.a. someone with solar) would pay the following fees: (1) system access fee for curb to meter infrastructure as a fixed monthly price; (2) grid use change per kW for distribution costs; and (3) time of use rate for energy delivered to the customer-generator. The solar customers would pay for system infrastructure, using the grid to sell energy, and energy they buy from the grid. In an unbundled rate option, the customer-generator would also receive a wholesale rate for the energy exported.

Alternatively, solar customers can opt into a Sun Credits Option rate structure. In this option the customer-generator would sell all their energy onto the grid, and be reimbursed in a bill credit equivalent to the “retail system average commodity rate”. A Sun Credit's customer would first act purely as a small power plant, and then as a customer. The OAT rate that solar customers buy energy from the utility would be at an increased rate to account for the ancillary services the utility provides. All utilities used would be charged at the otherwise applicable tariff (OAT). The OAT refers to the rate the customer would pay if not an energy provider, or simply – as much as every other customer is charged (SDG&E, 2015f).

Critical Peak Pricing

In southern California, residential solar systems have a unique opportunity to offset the impacts of climate change. By 2050, there is a forecasted seven percent increase in energy use in San Diego from higher temperatures (Messner et al., 2011). This increase in demand could increase overall energy prices, but poses the greatest threat on extreme heat days. Climate projections predict a threefold increase in hot days in parts of inland San Diego, where the greatest increases in population are also predicted (Messner et al., 2011). If these heat waves set off price spikes, that solar homes would not be subject to when using their systems.

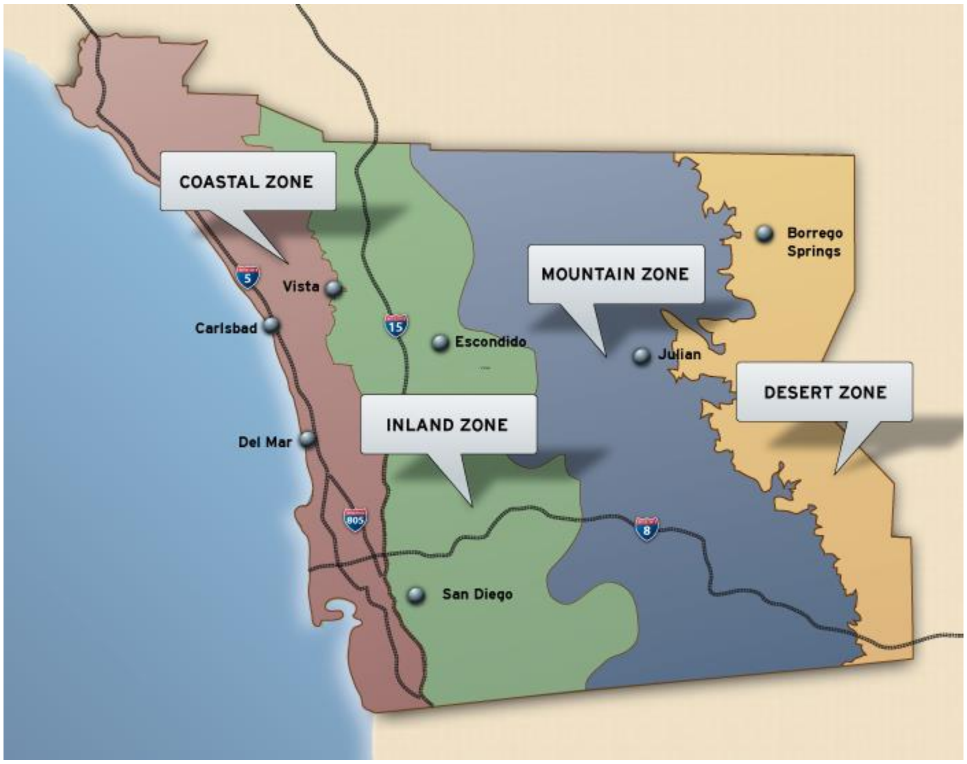
Critical peak pricing is when the utility experiences high electricity demand and the utility’s service population is at risk for brownouts if demand passes the system capacity. To ensure reliability, the utilities charges higher rates to discourage customers from using excess energy. The most common causes of triggering a critical peak pricing event are system load and temperature (SDG&E, 2015b; 2015d). Vulnerable populations, such as older adults on fixed incomes, may not be able to afford their energy on the hottest days of the year. Not only would solar homes avoid these price effects, excess energy from solar homes would go onto the grid, reducing the risk of brownouts.

Potential Solar Benefits and Energy Pricing in San Diego

The current solar incentive structure, without a smart-grid and limited NEM policies, sets up a framework where households produce a private benefit. The current tiered price of energy and limited sharing opportunities, provide the benefit in the form of cost-savings to large energy consumers. The private benefits, in the form of reduced energy bills, flow to the more affluent and suburban, because they use the most energy and are charged the highest prices (Balta-Ozkan, Watson & Mocca, 2015).

Until September of 2015, SDG&E billed their customers in four tiers. Tier one is a baseline unit, set between 50 and 60 percent of the average residential customer in your geographic territory (see Figure 5). Once that baseline energy amount is used, additional energy is charged at a higher tier two rate until that allowance is passed, then energy is charged at tier three and so on (see Table 3). In this system, higher energy users pay the most per-watt. This rate structure was developed to curb excessive energy use, but also provide the greatest potential savings opportunities to high-use households.

Figure 5: 2015 SDG&E Climate Billing Zones



Source: SDG&E, 2015c

Table 3: SDG&E Energy Tiers 2015

	Tier 1	Tier 2	Tier 3	Tier 4
Energy Used	0 – baseline	101%-130% of baseline	131%- 200% of baseline	>200 of baseline
Price	14c/kWh	17c/kWh	34c/kWh	36/kWh

New Construction

The CSI program seeks to retrofit existing buildings with solar, while the California Building and Energy Code provide mandatory measures and guidelines for new construction. The 2013 Energy Code, which functions in concert with the building code, mandates ‘solar zones’, which require that no less than 15% of the roof is shade free. It does not require any infrastructure such as conduits, but does put in place a structural form that is amenable to solar if an eventual resident wants to pursue a PV or thermal system in the future, especially as the price of solar panels drop (CEC 2013; 2012).

Starting in 2020 the California Building Code will implement a zero net energy (ZNE) program. The building code mandates that residential structure will produce more energy over a year than they consume. ZNE homes have a focus on energy efficiency with the remaining reduced demand augmented by on-site renewables, which have primarily been PV systems (CPUC 2013b; 2013c).

Data Analysis

Previous Research

This research examines the demographic and permit characteristics of communities with high levels of residential solar adoption in San Diego. The goal of this study was not to isolate explanatory variables, but uncover how individual, household, and local government variables work in concert to promote high levels solar adoption. Utilizing quantitative variables to build a statistical model, this research can illustrate which communities have been able to benefit from the current solar incentive programs in a robust market with an abundant solar resource.

Previous research on residential solar installations is a mix of policy reviews and empirical research, almost all on a larger geographic scale. Law and policy review both in California and nationwide illustrate that net metering policy, renewable portfolio standards, and predictive local government practices have a positive effect on overall PV adoption rates in general, but not the benefits they provide to specific communities or how those variables interact (Brown & Chandler, 2008; Burkhardt et al., 2015, Krasko & Doris, 2013; Li & Yi, 2014). California is a leader in much of solar policy, which this previous research can illustrate is effective in increasing adoption rates, but not who if benefiting from these “best practices”.

The demographic communities that adopt the highest levels of solar have been described apart from local governmental variables. Recent research has illustrated that nationwide: higher median income, higher home values, a greater percentage of white people, and a high proportion of liberals are predictive characteristics of high solar adoption communities (Kwan, 2012). How these demographics interact with policy choices is often missing. Research from U.C. Berkeley, has sought the most similar research goals using data from PG&E to evaluate the benefit of NEM policies on various income groups, but did not evaluate how local government practices may affect or be affected by the demographics of the community.

Methods

The community demographic and solar profiles for this research were created using three sources of data. First demographic data were collected from the 2014 American Community Survey (ACS) five year estimates. This is the most recent and robust demographic information available. Different from the 2010 Census, which provides basic demographic information, the ACS data offer detailed household information of specific interest to this researcher. Specifically, this research required in both individual demographic data (e.g. gender and age) as well as housing/ land use data (e.g. housing density and proportion of owner occupied units). See Table 4 for a full list of variables.

Table 4: Demographic Variables of Interest

	Description	Source	Mean	Std. dev.	Min	Max
Population Density	Persons per square mile	2014 ACS 5 yr. Estimates	3508	3189	2.4	12807
Female	Percent of population that is female	2014 ACS 5 yr. Estimates	49.9%	3.6%	31.0%	68.0%
Young adults	Percent of population aged 18-34 years	2014 ACS 5 yr. Estimates	25.4%	10.0%	7.0%	75.0%
Middle-aged adults	Percent of population aged 35-64 years	2014 ACS 5 yr. Estimates	38.9%	6.5%	0.0%	55.0%
Seniors	Percent of population aged 65 years or older	2014 ACS 5 yr. Estimates	14.2%	5.9%	5.0%	32.0%
White	Percent of population identifying as 'white alone'	2014 ACS 5 yr. Estimates	75.10%	15.00%	23.00%	100.00%
Median household income	Average income in 2014 inflation adjusted dollars	2014 ACS 5 yr. Estimates	68,603	23,112	24,032	131,166
Owner Occupied	Percent of households occupied by the homeowner	2014 ACS 5 yr. Estimates	59%	17%	23%	90%

	Description	Source	Mean	Std. dev.	Min	Max
Total Number of Installs	Installations in zip code	CSI Database	177	159	1	830
Average CSI Rating	Average system size	CSI Database	5.33	5.04	1.08	52.91[1]
Yes Ratio	Percent of third party owned installations	CSI Database	33%	16%	0%	100%
Installs per 1000	Installations per 1000 people[2]	CSI Database	7.4299	6.1869	0.5	33
Log installs per capita	Log of installs per person to normalize data	CSI Database	-2.2697	0.3714	-3.301	-1.4815

[1] This community is dense urban area with five multifamily projects
[2] The average household size is in San Diego in the 2014 ACS data is 2.8 resulting in an average installation rate per 1000 household of 2.65

Permit policy was tabulated at the permitting jurisdiction level, because the entire study area was within the same state and utility provider's jurisdiction. The research focused on common local government permit policies that are widely accepted as best practices (see Table 5). Policy variables were collected using Vote Solar 'Project Permit Score Cards' (2015). Vote Solar is a national non-profit that works to implement policy promoting solar power. Their Project Permit campaign ranked local municipalities permitting processes for solar panels on seven criteria. Each of these variables was collected for San Diego County's 19 permitting jurisdictions.

Table 5: Permit Variables from Project Permit Score Cards

Variable Name	Percent of 'Yes' Zip Codes in San Diego Region
Reasonable permit fees	91.8%
Posts requirements online	90.7%
Offers narrow inspection window	90.7%
No community specific licenses needed	100%
Fast turnaround time	80.4%
Enables online processing	41.2%
Eliminates excessive inspections	49.5%

Solar installation data was generated using the California Energy Commission's 'California Solar Statistics' database on residential solar projects that received subsidies through the CSI (Go Solar California; 2015a). This program offers upfront incentives for solar installations to customers of the State's three IOUs on existing residential homes, as well as existing and new commercial, industrial, government, non-profit, and agricultural properties. The funds available through the CSI, only apply to grid tied systems, and are not designed to provide back-up power during a power outage (CPUC, 2015a; Go Solar California, 2015b).

The dataset is the most robust set of individual, project-level information for non-utility scale systems, because it accounts for every installation using the 2.3 million dollars in incentives through the CSI. Due to its extensive nature, CSI data have been used as a proxy for PV deployment in California IOU territories in other published research (Dong & Wiser, 2013; Drury et al., 2012; Rothfeild, 2010). The data are biased toward established communities, because it does not include new construction, and do not represent "off-the-grid" systems that may be preferable to rural populations (Schelly, 2014).

The database of 21,053 records was narrowed to represent those systems that were completed and hosted on residential properties. This resulted in 17,192 individual installations. These individual installations were grouped by zip code. Each zip code with at least one installation was summarized by: the installation rate per capita, average system capacity, and the percent of installations owned by third parties. Of the 106 zip codes in San Diego, 97 had solar installations. Analysis was done on these 97 zip codes. There was no observed pattern between zip codes with no installations, although they were usually lower in population, with the exception of Camp Pendleton, which is a United States Naval Base.

Due to the large size of some jurisdictions, notably the City and County of San Diego, which are both home to many distinct populations, communities were defined by their zip codes. This was the smallest comparable geographic unit information collected by the California Solar Statistics database and the U.S. Census Bureau. Zip codes are defined by the postal service, and do not match jurisdictional boundaries completely. For example, one zip code crosses the county boundary into Imperial County and some Indian reservation lands are not covered by zip codes.

To assign zip codes to the city or county it best matches, centroids for each zip code polygon were created in ArcGIS. The location of the zip code's centroid was used to determine which jurisdiction issues building permits to that zip code and therefore, the matching policy score from Vote Solar. There was one exception to this methodology, the zip code 92014 is comprised of two separate polygons, one in the City of Del Mar which has poor permitting practices, and one section in the City of San Diego which has best permitting practices. The City of Del Mar was determined to be the permitting jurisdiction because 97.3% of all installations in the 92014 zip code were identified to be in the City of Del Mar.

Results

The data analysis found that the San Diego region generally follows State and National trends, but differs in two key variables. Other studies have not identified seniors as a significant correlate in adopters, yet in San Diego persons aged 65+ are the best predictors of high adoption communities. Secondly, many other studies find that adopters of PV are predominantly white, where in San Diego communities with a high proportion of members identified white alone were not significantly more likely to have high levels of PV adoption. This is especially interesting considering that 33% of those who identify as white alone, also identify as Hispanic or Latino.

Initial Findings

The initial findings were ascertained with statistical models to identify key demographic characteristics, then mapped to evaluate key geographic clustering as possible typologies such as rural retirement communities and wealthy urban centers.

Statistical Data Analysis

This research seeks to create an explanatory model of solar adoption in San Diego by scaling down the methodology of two previous studies (Dong & Wiser, 2013; Kwan, 2012). To create this model, a stepwise regression model was used. This method analysis one variable at a time and creates an explanatory model by identifying the variable with the highest correlation (i.e. most explanatory), then adds additional variables in order of correlation to the dependent variable. In the case of this research, a number of demographic variables were run independently against the installation rate per capita to identify a suite of demographic characteristics that explain communities with high levels of solar adoption.

The model identifies the best predictors of solar installation, not necessarily the causes of variability. Stepwise regression can mask co-linear variables by only illustrating the variables that have the highest correlation. For example, if people are less likely to rent as they age, age and owner occupied would be co-linear variables. Stepwise may only illustrate the variable with higher correlation as significant, when both play an explanatory role. In this research, the method provides an accurate demographic picture, but the motivation for installation and collinear variables are left to interpretation.

Utilizing a stepwise regression method, the model displayed in Table 6 is the best explanatory fit. Of these explanatory variables, three were statistically significant: lower population density, the proportion of the population over 65 years, and median income. As illustrated in earlier research, low population density and median income are well documented in the literature as common predictors of residential solar adoption, because they represent large suburban households with both high energy demand and capital to invest in household PV systems (Bornstein & Notsund, 2014; Graziano & Gillingham, 2014; Kwan, 2012). Adoption rates are also usually coordinated with age in that younger households, such as people in their 20s and 30s do not yet have the accumulated wealth; however, the strength of the relationship between seniors is not usually found or extensively addressed in large geographic studies. Interpretation of these findings is discussed in 'Demographic Variables' below.

Of the variables that are not significant, 'white alone' stands out. While most studies find that the populations that adopt solar technology are disproportionately white, this is not statistically significant in San Diego. It is possible that the populations in the communities of San Diego are racially mixed to a greater extent than other study areas, such as the State of California, which is generally more segregated. It is also interesting that local government permitting and communities with high levels of third party owned systems also have no significant effect.

Table 6: Stepwise Findings

Term	Estimate	Std Error	t Ratio	Prob>|t|
Population Density	**-3.67E-05**	**0.000012**	**-3.07**	**0.0029**
65+ years	**1.570759**	**0.589835**	**2.66**	**0.0092**
White Alone	0.271027	0.200268	1.35	0.1795
Median Income	**3.94E-06**	**1.32E-06**	**3**	**0.0036**
Permit Rating[Best]	0.045525	0.050503	0.9	0.3698
Permit Rating[Good]	-0.0011	0.057439	-0.02	0.9848

Yes Ratio	-0.22799	0.186287	-1.22	0.2243
Owner Occupied	0.395773	0.251232	1.58	0.1188

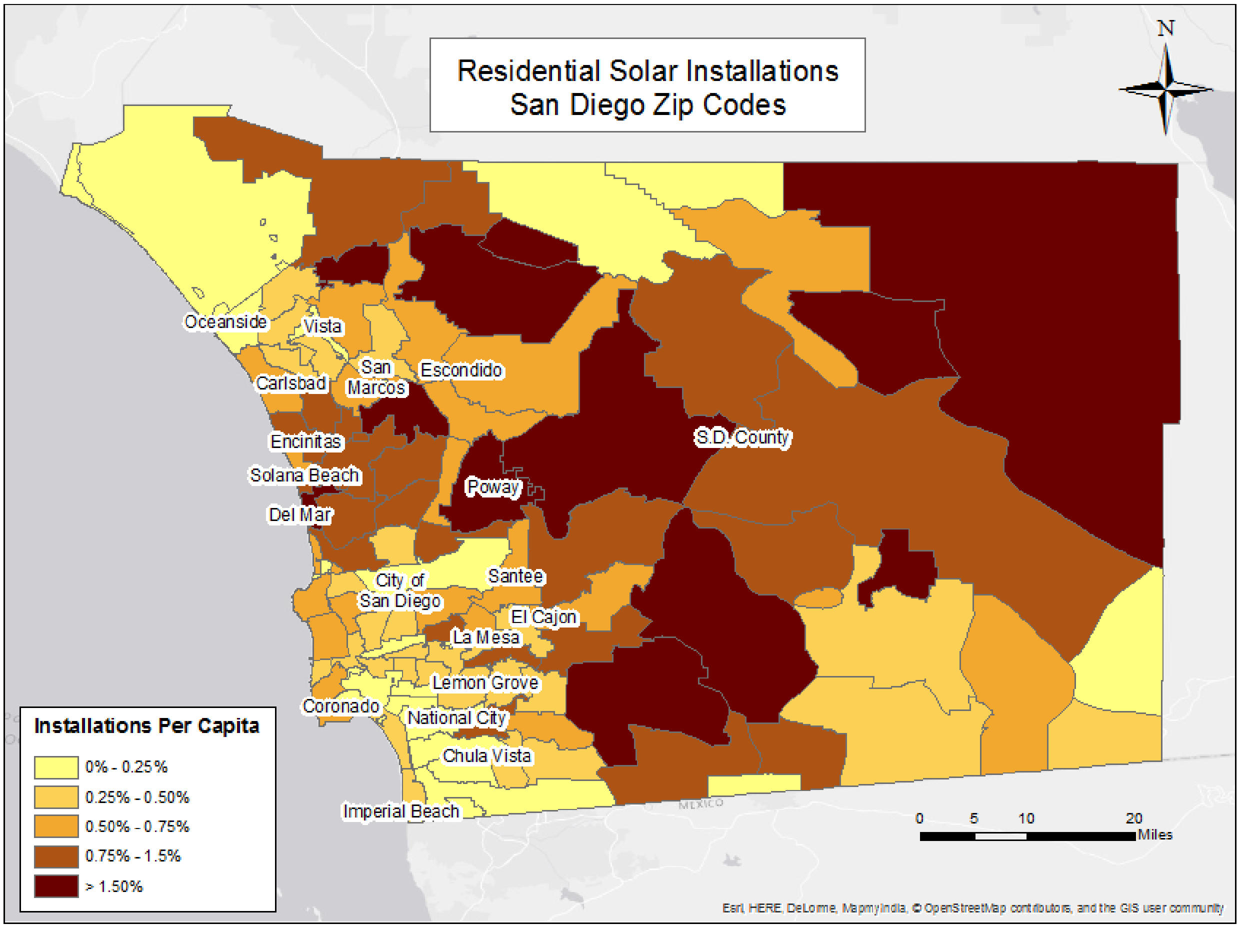
Geography

Zip codes with similar residential solar adoption rates follow informal community boundaries defined by demography and understood by local residents. These informal demographic communities appear as clusters of zip codes with similar racial, economic, housing, and solar adoption characteristics. Maps of high solar adoption follow patterns of colloquial local groupings of communities, suggesting a strong relationship between community characteristics and residential solar adoption.

Groupings of communities with high per-capita adoption rates fell into three geographic zones: (one) along the coast of the City of San Diego, (two) the north western communities of San Diego County, and (three) the north east County of San Diego County. All three locations are generally higher income suburban communities. Conversely the lowest levels of adoption are in the southwest portions of San Diego, comprised of dense, generally lower income, and multiple, smaller jurisdictions (see Figure 6).

The collinearity of variables is important to understand, because of how these variables interact with each other in the decision of a single individual to install solar on their home. For example, income and population density are generally inversely correlated. Since the 1950s, increased income translates to decreased density, as people move to the suburbs or to larger lots as they make more money. The price of photovoltaic panels, higher energy requirements in larger homes, and investment in single family homes all have the potential to make solar more appealing to wealthy people in single family homes – without one clear cause.

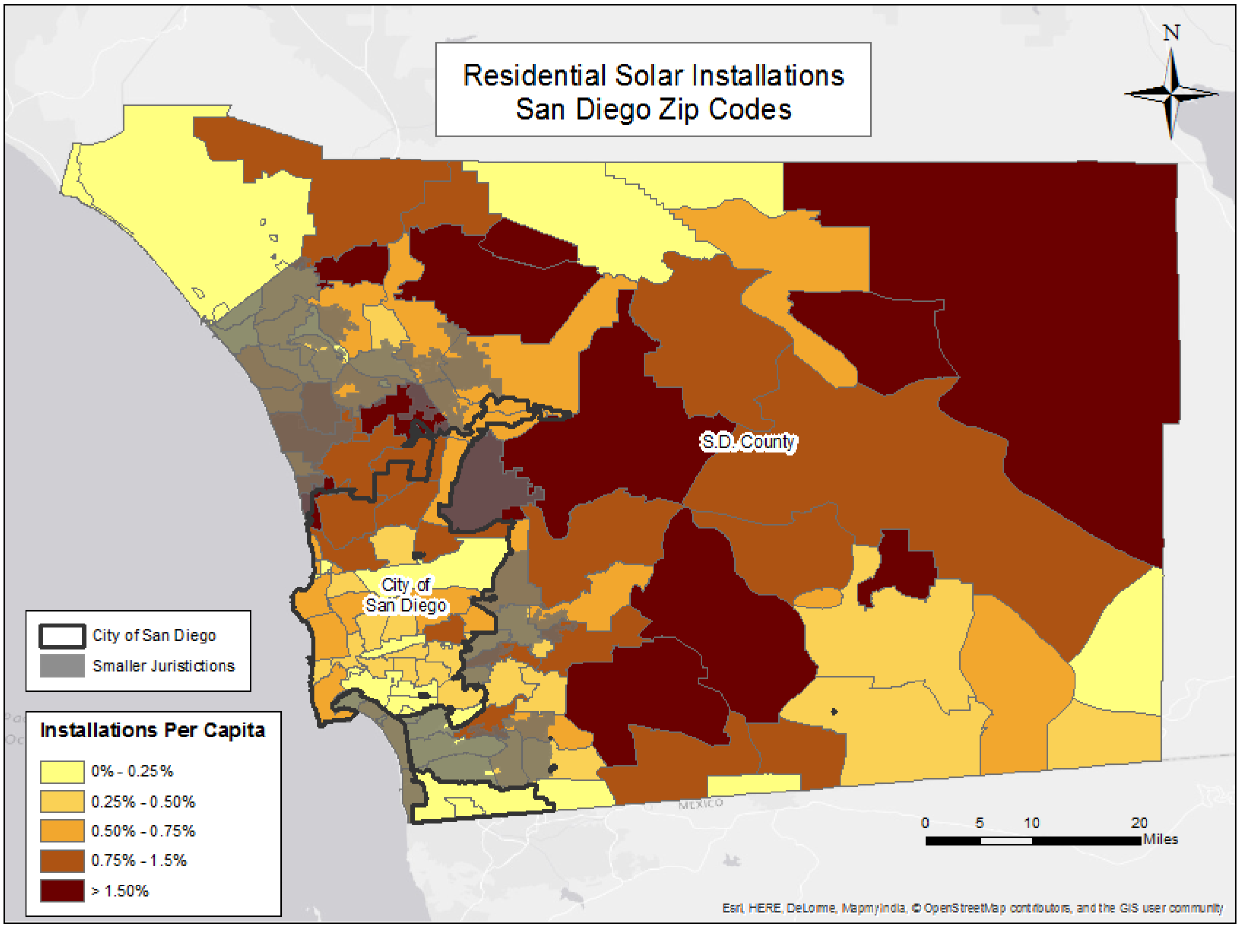
Figure 6: Residential Solar Installations in San Diego Zip Codes



Local Government and Permitting

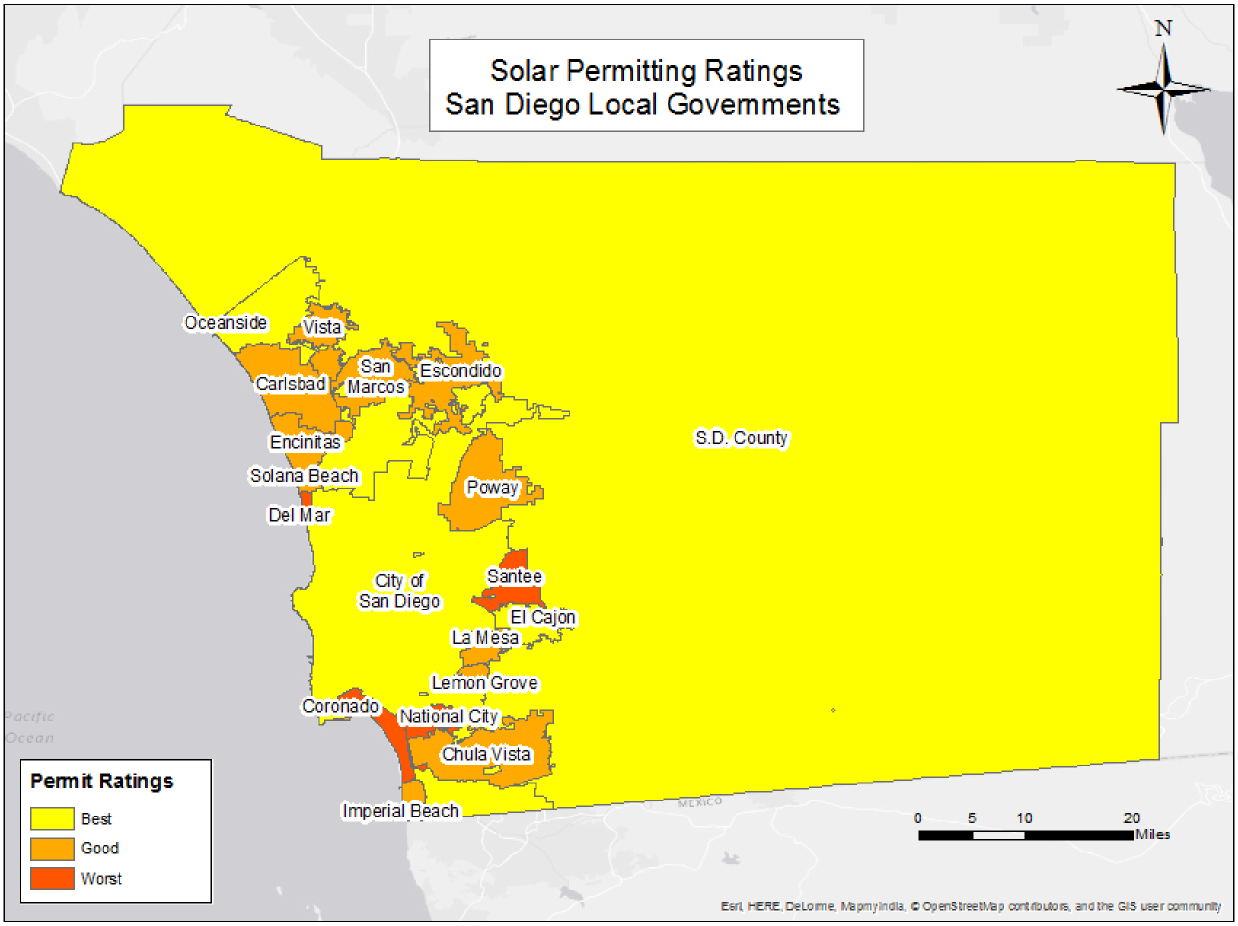
None of the permit variables Vote Solar tracks were significant in San Diego. This can partially be explained by how much of the study area is in only two jurisdictions (See Figure 7). Of the 97 zip codes with at least one solar installation, 68% were in either the City or County of San Diego. The lack of uniform adoption rates in these large jurisdictions, and that higher rates of adoption seem to more faithfully follow demographic communities than jurisdictional boundaries suggests that in this study area, local government has less of an effect than community make up.

Figure 7: Residential Solar Installations in the City and County of San Diego



Both the City and County of San Diego are rated as having best permitting practices, meeting all seven of the permit measurements defined by Vote Solar. The cities of El Cajon and Oceanside also have best permitting practices, for a total of 77% of study zip codes falling under this designation. By contrast, only four zip codes (4%) have worst practices (see Figure 8). Two of these zip codes represent affluent communities, which are likely to have well-funded governments – potentially nullifying the effect of less than optimal permitting regulations.

Figure 8: Solar Permit Ratings of Local Governments in San Diego County



Demographic Variables

The statistical model highlighted three significant variables: population density, median household income, and persons over 65. Population density was negatively correlated with adoption rates. This indicates that suburban and rural communities are more likely adopters. Residents in these communities often have larger lots and incomes. Suburban and rural properties have more room for ground mounts and more single family homes. Single family homes, indicative of these landscapes, do not require consultation with other residents, as it is in multifamily units. This result could also indicate that large suburban and rural jurisdictions – most notably the County of San Diego have better established streamlined permit process, more institutional knowledge, and improved program advertisement.

Generally speaking, the more people in suburban and rural communities own their own home. While this relationship holds true in San Diego, owner occupied homes were not a significant predictor of increased adoption (see Figure 9). Installing PV on one's property would require consent of the homeowner, and poses a greater reward for the people paying the utility bill. However, even though homeownership would seem to be a likely prerequisite, communities with a higher proportion of owner occupied units do not have a statistically significantly correlated with PV adoption.

Figure 9: Relationship Between Home Ownership and Population Density

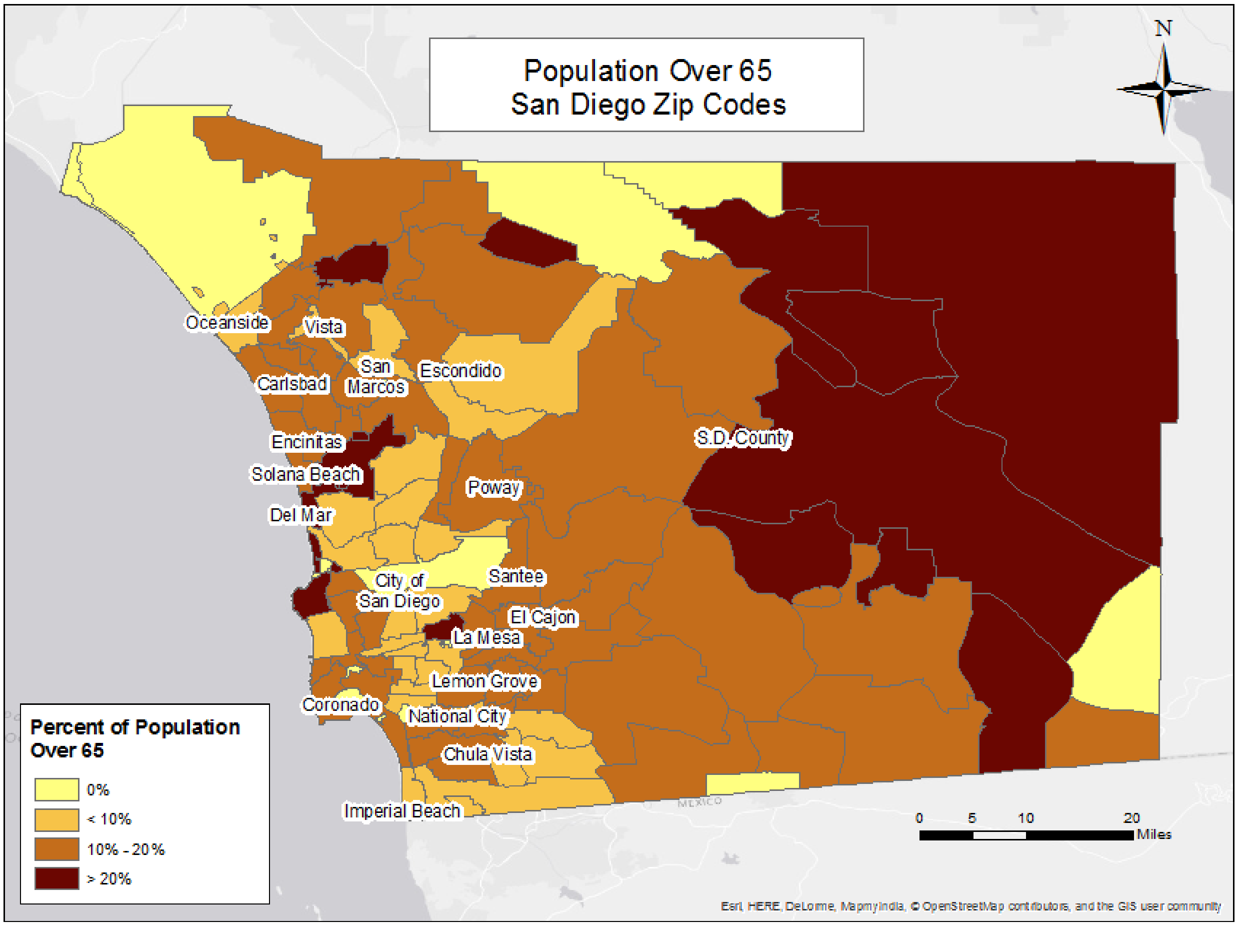
Source: 2014 American Community Survey 5 Year Estimates

The lack of statistical significance of homeownership could be because this study does not assess adoption on an individual scale. Unlike housing-type or income which are generally homogenous across a zip code, home ownership can vary within a neighborhood. All of the solar installations could be on owner occupied properties, but homeownership is not uniform across zip code. Homeownership is highly correlated with better predictors of solar adoption such as age or income than housing density (see Figure 9 and 11), but have a smaller correlation in a community based analysis. Simply stated, people with high incomes own both condos and homes – but the structure of a single family home is more amenable to installing PV, making density and income the better predictors. Income is often associated with high adoption rates as it is in this study, because the high price of solar panels and higher energy demands of larger homes both bias solar installations toward high-income households.

Communities with higher rates of seniors were also correlated ($p = 0.0092$) with higher levels of residential solar installations. As illustrated in Figure 10, the highest concentrations of older adults are along the coast of the City of San Diego and the northeast corner of San Diego County. The coast of the City has a high median income, where the northeast corner of the country lacks this covariant. This is potentially explained by a phenomena known as equity refugees, where seniors sell their homes for large profits and settle down in smaller homes and or less expensive rural areas (Flores, 2015).

Income is an annual marker and does not represent total wealth. While in the working years income is likely a good predictor of wealth, this connection diminishes once someone enters retirement. In the case of northeast San Diego, the community of Borrego Springs is a known retirement community. Seniors who lived and worked in more urban parts of San Diego, sell their homes and move east with enough money to retire on and, occasionally, purchase solar panels with.

Figure 10: Seniors in San Diego County



Discussion

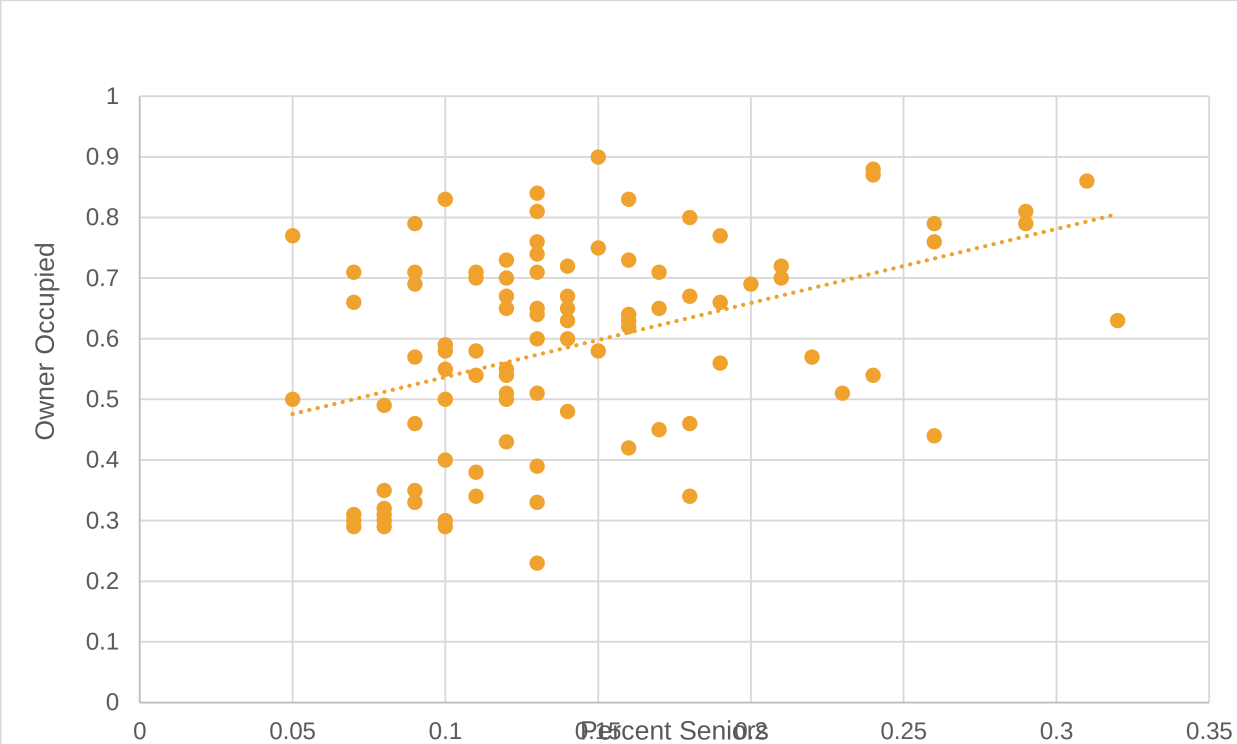
The results from this study mirror much of the findings of other statewide and national research. Similar to other studies, low density affluent communities are high adoption communities. Unlike previous research, San Diego is smaller a geographic study area and more developed solar market. The most distinct difference in this research findings is the correlation between the proportion of seniors and high levels of solar adoption – suggesting that retirees have been able to best benefit from the current incentive structure and permit structure.

Older Adults

Seniors exist in a financial dichotomy that predisposes them to both utilizing and benefiting from residential solar systems. Retirement is both indicative of high levels of accrued wealth, a fixed income, and time (Schelly, 2014). This means retirees who sell their large homes, and move to rural retirement communities have the capital to invest in panels, the desire to have predictable and lower utility costs for 20 years, and the time to navigate permitting and solar contractors.

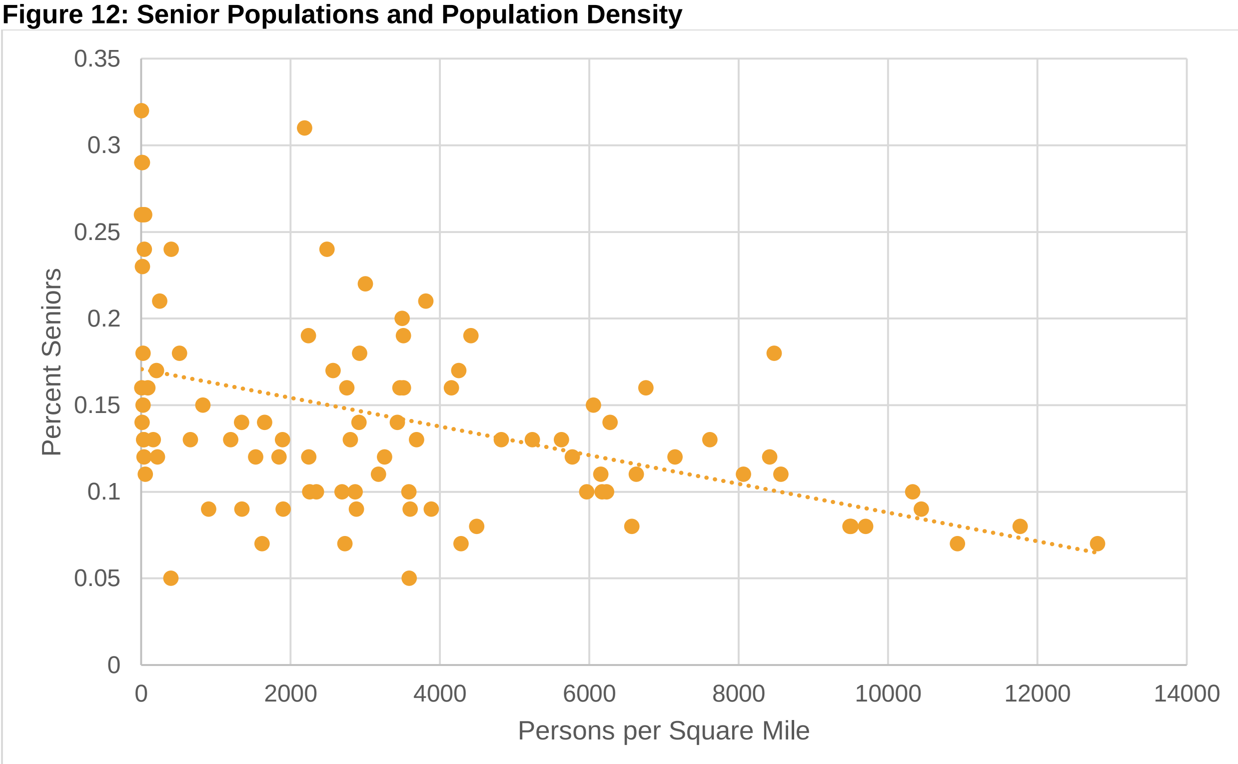
Senior dense communities also have high levels of home ownership (see Figure 11). While more age-diverse communities range in renter rates, senior dense communities are predominantly characterized by high levels of homeownership. Retirees often have also made their last major life change, and are more likely to stay in their home through the life of the panels. Beyond homeownership, senior dense communities are correlated with less dense landscapes (see Figure 12). This correlation may be in part caused by seniors retiring to rural communities in the County of San Diego, but may not completely be explained by age.

Figure 11: Senior Populations and Homeownership



Source: 2014 American Community Survey 5 Year Estimates

Figure 12: Senior Populations and Population Density

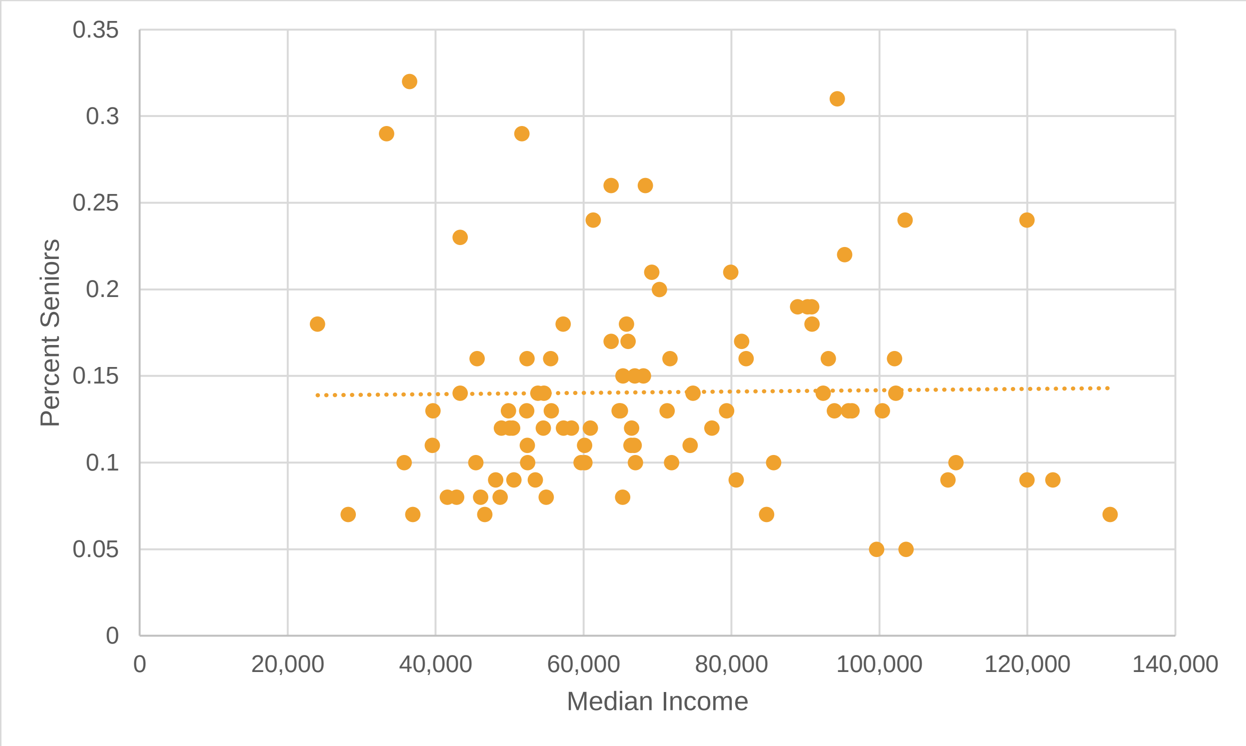


Source: 2014 American Community Survey 5 Year Estimates

Seniors are the confluence of multiple variables that may predispose them to higher levels of adoption. Retirement is a likely catalyst to PV adoption, but seniors are also a likely proxy for other factors. Because communities with high senior populations are generally less dense, this also means senior concentrated communities are likely to have access to better permitting practices. The low density zip codes are chiefly located in the County of San Diego which because of its land availability and focus on energy development has an established permitting system and solar-friendly zoning code (County of San Diego, 2013). Seniors are likely not seeking out a more amenable permitting process, but are never-the-less benefiting from it.

The other proxy variable seniors are explaining is wealth. The census measures yearly income, but not accrued capital to purchase solar panels with. High median income was statistically significant with high levels of PV adoption; seniors have no correlation with median income (see Figure 13). The life changes, and the lack of increasing income that accompany retirement are a likely factor in solar adoption, wealth is more indicative of capital available to buy panels than income or age, but the Census Bureau does not measure it.

Figure 13: Seniors and Median Income



Source: 2014 American Community Survey 5 Year Estimates

Next Steps

In recent years California has made sweeping and progressive changes to residential PV planning. As of fall 2015, all jurisdictions in the State must have an online administrative permit processing of small-scale (<10 MW) systems, and by 2020 the California Building Code mandates that all new construction must be zero-net-energy. This means that new PV policy ought to focus on existing structures and their residents that were underrepresented in the CSI. Due to the continuing price-reductions of solar systems, large incentive structures to reduce the initial cost may not be necessary, but a retooling of benefits to reduce energy costs for disaggregated solar is available to a more diverse population is still necessary.

Beyond the best permitting practices now required in California, cities could adjust other segments of their municipal code to encourage solar adoption. Following the example of the County of San Diego, jurisdictions could amend their height limits to allow for deviations for solar panels. Many existing structures were likely built to the height limit to maximize property values, but now lack permitted room for solar panels. Homeowners are not likely to demolish or undergo major renovations to shrink their homes and provide room for panels.

The populations that CSI benefits missed is also one of the fastest growing – young renters. Young professionals are likely to lack the capital or homeownership that is often seen as a prerequisite to retrofitting one's residence. Landlords do not currently have an incentive to install systems on properties they rent, because they rarely pay the utility bill. In the case of condos or duplexes where people may own, energy bills are generally low and the capital investment is not perceived as worthwhile.

There have been two major changes in energy and climate policy since the inception of the CSI that could be capitalized on to address the underserved populations. First the inception of California carbon cap-and-trade and time-of-use pricing. Cap-and-trade funds an offset market, which could be used to fund energy retrofits of renter occupied buildings. These funds could be used to target renter housing in the central valley where climate change is projected to increase heatwaves and energy demand.

For those low-energy homes in multi-family complexes or "tiny" home communities there is a framework for sharing the energy from one large system among unrelated households. This process is known as virtual net metering (VNM) and is available to groups of customers at the same point of service (i.e. apartment complex). The property manager or homeowner's association predetermines what percentage of the energy generated by the shared system. Each household pays for any additional energy they buy from the utility and base utility fees. If a household uses less than their allotted percentage, they receive bill credit that can be used on energy purchase averaged over a 12-month period.

Planners can help maximize this option by ensuring that duplex, townhome developments, or granny-unit communities share a point of service. Cities and counties could also use VNM systems in their list of deviations for planned developments. This would allow developers to trade something required, such as parking spots, by the city's code with a shared solar system. Another potential tactic local government could employ would be to waive development or permitting fees if they include a VNM system. Cities could also advertise this option at city hall and online, so that developers are aware of their options that may make their projects more appealing to tenants.

As energy policy, rate structures, and climate all change – policy makers and local government planners are likely to find that there is no silver bullet. Instead the future is likely ‘silver buckshot’ made up of multiple incentive structures and financing options, creating a menu of solar options that fit the needs and lifestyles of all community members. Outside of California, jurisdictions can capitalize on the lessons learned here to create policy that support low cost, reliable, and renewable. This strategy starts with proactive energy procurement goals for utilities, net-metering/virtual net metering policies, and access to capital through state-backed incentives or third-party developers – and never ends, just adapts.

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Appendix A – City of San Diego Solar Photovoltaic System Permit Bulletin

THE CITY OF SAN DIEGO

HOW TO OBTAIN A PERMIT FOR INSTALLATION OF

Solar Photovoltaic Systems

CITY OF SAN DIEGO DEVELOPMENT SERVICES
1222 FIRST AVENUE, MS 401 SAN DIEGO, CA 92101-4101

INFORMATION BULLETIN

301

OCTOBER 2015

This information bulletin explains the permit process and fees for the installation of Solar Photovoltaic (PV) Systems. It also provides information about submittal requirements, plan reviews, structural requirements, fire classification, and project inspections.

I. APPROVAL REQUIREMENTS

A. An electrical permit is required for the installation of PV systems.

B. A separate building permit is also required for the installation of PV system on existing non-residential or multi-family residential buildings/structures if the scope of work includes modifications to such structures to support the PV system or when scope of work includes new accessory structures such as carports, canopies, or shade structures.

C. A Combination Building Permit is required if the scope of work includes structural modifications to existing single-family/duplex/townhouse residential structures to support the PV system. In this case, a separate Electrical Permit would not be required.

D. A separate Building Permit or Combination Building Permit is required for ground-mounted PV system where the support structure is greater than 5 feet above ground.

PV systems are permitted city wide per Municipal Code, Section 141.0418 and shall comply with all applicable California construction code requirements, City ordinances and regulations including zoning, structure height, FAA notification and condition of prior development permits governing the site.

II. SUBMITTAL REQUIREMENTS

The following plans and documents shall be provided along with the appropriate fees.

A. Application Package

1. General Application (DS-3032)
2. Hazardous Materials Reporting Form DS-165 (required for Solar PV systems with batteries or when a Building Permit is also required)
3. San Diego Regional Hazardous Materials Questionnaire (HM-9171) (required when a Building Permit is also required)
4. Storm Water Requirements Applicability Checklist (DS-560) (required when a Building Permit is also required).

Documents referenced in this Information Bulletin

- San Diego Municipal Code, (SDMC)
- Information Bulletin 122, How to Prepare a Site Plan and Vicinity Map
- Information Bulletin 303, Professional Certification Process Solar Photovoltaic Plan Review
- Information Bulletin 501, Fee Schedule Construction Permits - Structures
- Information Bulletin 581, Designated Historical Resource Review
- Hazardous Materials Reporting, DS-165
- Storm Water Requirements Applicability Checklist, DS-560
- General Application, DS-3032
- San Diego Regional Hazardous Materials Questionnaire, HM-9171
- Solar Photovoltaic Plan Template
- Appendix - Electronic Submittal for the Permitting of Single Family Roof-Mounted PV Systems

B. Plans

1. **Single-family/ Duplex/Townhouse Residential PV installations per Plan Template (one system per dwelling unit)**
   The template was developed to guide the applicant in preparing residential solar PV plans. This template shall be used only for a residential PV project when installed on a sloped roof with the panel weight of six pounds per square foot or less. This plan template may be used as a general guideline to prepare residential solar PV plans. A reduced turnaround time is provided for residential projects using the Plan Template (see Section VII Options for Review). Provide the following items:
   a. Two copies of the plans per Solar Photovoltaic Plan Template. The plan template sheets shall be modified to reflect the actual project-specific details.
   b. One copy of manufacturer's specifications for the proposed PV panels with all electrical information.
   c. One copy of manufacturer's specifications for the proposed PV inverter(s) showing all electrical information.

2. **Non-residential or Multi-family residential PV installations**
   Provide two complete sets as follows; four sets if a Building Permit is also required.

a. **Site Plan.** The site plan for ground mounted PV system must show property lines and setback dimensions. For roof mounted PV systems, the site plan must show the footprint of the building and the location of the PV system on the roof.
The plans must also include the site address, legal description, assessor's parcel number, and property owner's name/address. See Information Bulletin 122 for How to Prepare a Site Plan and Vicinity Map.

b. **Roof Plan.** Provide a roof plan showing the slope of the roof and location of the existing and proposed PV panels on the roof in relation to any ridge, hip or valley, as well as the location and size of any existing roof mounted equipment.

c. **Single Line Diagram.** An electrical one-line diagram showing the number of photovoltaic panels (include the manufacturer model number) with voltage and kilowatt output, all disconnects, all combiners, all inverters (include the manufacturer model number) with input ratings, the ampere rating of any sub-panels connected to the PV system, the ampere rating of the meter panel bussing, the ampere rating of the main service disconnect, the ampere rating of the PV circuit breaker, size and type of all raceways and the size and type of all conductors.
Include a plan showing the location of all existing and proposed PV panels, AC or DC combiners, all disconnects inverters sub-panels connected to the solar PV system and the meter panel.

d. **Manufacturer's Electrical Data Sheets.** Provide one copy of the manufacturer's specifications for the proposed PV modules, inverter(s) and meter with all of their electrical information.

e. **Design Professional Stamp and Signature on Plans.** All plans shall be stamped and signed in accordance with the California Business and Professions Code by the registered design professional. PV plans may be stamped and signed by a California registered electrical engineer or a licensed electrical contractor (C-10 License) or a licensed solar contractor (C-46 License) who is responsible for the installation of the system. A California licensed general contractor (B-License) may also sign the plans only if the PV panels are installed in a new building or new addition to an existing building. A California registered architect, civil engineer or structural engineer shall stamp and sign structural plans and calculations.

III. STRUCTURAL PLANS AND CALCULATIONS

A. Structural Plan Review

Structural review for the installation of a PV system on the roof of buildings and structures will be required where any of the following conditions occur:

1. Alterations to the structure are required to support and provide an attachment for PV systems;
2. Weight of PV panels/modules exceeds six pounds per square foot;
3. Weight of any piece of ground mounted or rooftop mounted equipment exceeds 400 pounds;
4. Mounting height at any point above the roof is greater than 24 inches;
5. The PV system is installed on the roof of buildings or structures with a ballasted system.
6. Ground mounted PV systems located more than five feet above the ground.

B. Structural Plans

1. Where alterations are required to existing structures or where new structures are constructed to support and provide attachment for PV systems, or for installation of ground-mounted PV systems, structural plans shall be provided that are sufficient in detail and scope to demonstrate the required load path to the ground.
2. Framing Plan. If structural plan review is required for the installation of PV system in accordance with the conditions stated in Section III.A of this information bulletin, a framing plan shall be provided with the following detail:
   a. Roof framing plan (for roof-mounted PV system) specifying size and location of all framing members and vertical support elements.
   b. PV support structure framing plan specifying size and location of all framing members.
   c. Location, size and weight of any existing or new roof-mounted equipment.
   d. Maximum weight of individual photovoltaic panels.
   e. Number and location of all photovoltaic panels.
   f. Size, weight and number of ballasts at each location.
   g. Attachment of the panels to the support structure.
   h. Attachment of the PV support structure to the roof or to ground.
3. If using pre-manufactured racking systems, provide the manufacturer's installation specifications.
4. Cross Section. Provide a cross-section showing the height of the proposed PV panels above the roof or ground, the supporting structure, slope, and the distance down the slope from any roof ridge.

C. Structural Calculations

For roof top mounted or ground-mounted solar photovoltaic panels or modules, supporting structures (existing and new) shall be evaluated to accommodate the weight of the solar photovoltaic (PV) system. Such evaluation shall be substantiated by structural calculations.

The existing roof framing system must be evaluated for roof dead load, PV dead load (panels, ballasts, support platform, etc.) and roof design live load. For roof areas covered by the PV panels, where the clear space between the PV panels and the rooftop is 24 inches or less, roof design live load may be ignored.

The adequacy of the following shall be evaluated by a California licensed civil/structural engineer or architect:

1. Existing gravity load-carrying structural elements (joists, beams, girders, trusses, columns, foundation) where installation of the PV system causes an increase in design gravity load of more than 5 percent and,
2. Existing lateral load-carrying structural elements (horizontal diaphragms, shear walls, braced/moment frames) where installation of PV system causes an increase in the design lateral load of more than 10 percent.

D. Fire Classification of Solar Photovoltaic Panels

1. **Fire Classification.** The provisions of CBC, Chapter 15 'Roof Assemblies and Roof top structures shall govern the design, materials, construction and quality of roof assemblies and, rooftop structures. Roof top solar photovoltaic systems shall meet the minimum fire classification in accordance with Table 1 in this information bulletin and CBC Sections 1505.8 and 1505.9.
2. **Screening Requirement.** Where specified on Table 1 of this information bulletin, the space between the solar photovoltaics panels/modules and the roof underneath shall be fully enclosed with corrosion resistant metal wire mesh or other non-combustible materials to prevent intrusion of flying ambers and accumulation of debris under the photovoltaic panels. The dimension of the opening through the screening material shall not be greater than ¼ inch. The screening materials shall be firmly secured in place.

E. Zoning Review

All ground mounted Solar Photovoltaic systems will be reviewed for compliance with zoning and brush management regulations.

F. Historical Review

1. Electrical Permits-Historic review is not required for the installation of PV systems which only require an Electrical Permit. However, applicants proposing to install or modify a photovoltaic system on a premise containing a designated historical resource or within a historic district are encouraged to meet with Historical Resources staff prior to submittal of the project to the Development Services Department. Historical Resources staff will work with the applicant to reduce, to the extent possible, any adverse impact to the historical property through project design and location. Historical Resources staff will then stamp the plans as conforming to the San Diego Municipal Code and will recommend application of the State Historical Building Code. There is no charge for this meeting and review of the photovoltaic projects by Historical Resources staff. Please contact Historical Resources staff at HistoricalResources@sandiego.gov or by phone at 619-235-5224 if you would like to arrange for a meeting.
2. Building Permits-Historic review is required for installation of PV systems that also require a Building Permit as follows:
   a. Designated Historical Resources or Historical District. If the project site/structure is Designated Historical or located within a Historical District, it is subject to this review. See Information Bulletin 581, Designated Historical Resource Review, for additional information.
   b. Potential Historic Review. If the project site contains a structure 45 years old or more, it is subject to historic review. See Information Bulletin 580, Potential Historical Resource Review, for additional submittal requirements.

IV. INSPECTIONS

Required inspections may include: Electrical Underground; Electrical Rough; Electrical Final; Structural-Foundation; Structural-Rough and Structural-Final.

After receiving final inspection approval for all related City of San Diego Approvals (permits), San Diego Gas and Electric (SDG&E) will be notified. The system is not approved to energize until SDG&E approval is obtained.

V. FEES

The following fees are for Electric-Photovoltaic Permits only. Additional fees will be assessed when a Building or Combination Building Permit is required (see Information Bulletin 501 for Building and Combination Building Permit fees).

A. Residential Submitted

Issuance/with Plans	$39
Travel-documentation	$50
Records Fee	$20
First System/Inverter Plan Check	$174
First System/Inverter Inspection	$174

Projects requiring structural, zoning, brush management/landscape or historic reviews may include charges for those reviews based upon an hourly rate.

B. Residential Per City of San Diego Residential PV Plan Template

Issuance/with Plans	$39
Travel-documentation	$50
Records Fee	$20
First System/Inverter Plan Check	$111
First System/Inverter Inspection	$174

C. Professional Certification

Issuance/with Plans	$39
Travel-documentation	$50
Records Fee	$20
First System/Inverter Inspection	$174

D. Non-Residential/Multi-Family Residential

Issuance/with Plans	$137
Travel-documentation	$50
Records Fee	$60
First 100 Kw Plan Check	$334
Each Additional 100 Kw Plan Check	$116
First 100 Kw Inspection	$261
Each Additional 100 Kw Inspection	$101

Projects requiring structural, zoning, brush management/landscape or historic reviews may include charges for those reviews based upon an hourly rate.

E. Express Plan Check

When available, a reduced review period can be accomplished by paying an Express Plan Check fee at 1.5 times the regular plan check fee.

VI. OPTIONS FOR REVIEW

A. Non-Residential or Multi-Family Buildings, Ground-Mounted or PV Systems with Battery Back-Up

Plans for Solar Photovoltaic Systems on non-residential or multi-family buildings, including PV projects with batteries, and all ground-mounted PV projects must be submitted for review. Plans shall be submitted on the third floor of the Development Services Center located at 1222 First Ave. Appointments to submit applications and plans is highly recommended, and can be scheduled by calling (619) 446-5300.

B. Single-Family/Duplex/Townhouse Residential Roof-Mounted PV Systems

Single-family roof mounted solar PV projects prepared in accordance with the City's Residential PV Plan Templates are processed for permitting at the Inspection Services Office located at 9601 Ridgehaven Court, Suite 220 as follows:

1. **Walk-in.** Applicant may drop off for review their completed application and plans with a cover sheet that identifies each project by address.
2. **Professional Certification.** This program allows eligible design professionals to obtain a permit for Solar PV installations with limited plan review. Professional Certification projects are processed at the Inspection Services Office located at 9601 Ridgehaven Court, Suite 220. Applicant should schedule an appointment by calling 619-446-5300, where projects are setup and permits for up to three (3) professional certification submittals may be issued during the appointment. Refer to Information Bulletin 303 for additional information.
3. **Electronic Submittal.** Roof-mounted PV systems that do not require a Combination Permit may also be submitted electronically via the City's File Transfer Protocol (FTP) site. Customers should submit all of the documents listed in Item II above by compressed PDF file. For instructions on how to submit plans electronically, please see Appendix-Electric Submittal for the Permitting of Single Family Roof-Mounted PV Systems, referenced in the documents section of this information bulletin.

   A confirmation of the receipt of the application package received electronically will be sent to the customer via email with a project number.

Table 1. Minimum Fire Classification of Solar PV Panels/Modules (Systems)

Type of Use		Minimum Fire Classification	Standards
1.	Building integrated photovoltaic systems	Class A	ASTM E 108 or UL 790
2.	Roof top mounted solar photovoltaic systems on a building/structure located in VHFHSZ[1]	Class A	UL 1703
3.	Roof top mounted solar photovoltaic systems on a building/structure not located in VHFHSZ[1]	Class C or better (Must be screened[2])	UL 1703
4.	Solar photovoltaic systems supported by non-combustible structural framing without roof covering.	Class C or better	UL 1703
5.	Ground mounted solar photovoltaic systems with no uses underneath[3].	Not applicable	Not applicable

Footnotes:

1. Very High Fire Hazard Severity Zone. See map on the San Diego Fire- Rescue Department web page under Services and Programs.
2. A screen is required to be installed to enclose the space between the rooftop and the PV panels in accordance with Section III.D.2 of this Information Bulletin.
3. Uses underneath refer to any type of uses underneath the solar panels/modules, where the clear space between the panels/modules and the rooftop is more than 24 inches.

3. Secured Agreement. The applicant shall also enter into a secured agreement with the County that requires the decommissioning plan to be implemented and completed. The terms and conditions of the agreement shall be to the satisfaction of the Director and subject to the review and approval of County Counsel. The Director is authorized to sign the agreement on behalf of the County. The security provided with the agreement shall be in an amount sufficient to cover the County's costs, as determined by the Director, to implement and complete the decommissioning plan in case the owner or operator fails to implement and/or complete the plan. The security shall be in a form approved by the Director. Typical forms of security include a surety bond, irrevocable letter of credit or trust funds. The security shall remain in effect for the entire time that the large wind turbine is operational and for any additional time until the decommissioning has been completed in accordance with the decommissioning plan.

4. Building Permit. No building permit for any component of a large wind turbine may be issued until the Director approves the decommissioning plan, signs the secured agreement and accepts the security.

k. Existing Administrative Permits for Wind Turbine Projects - Modification or Revocation. Administrative permits for wind turbine projects granted pursuant to Section 7060 prior to January 1, 1986, shall be treated for all purposes as if they are Major Use Permits and shall be subject to all the provisions of the Zoning Ordinance which apply to Major Use Permits for purpose of modification or revocation.

l. Design. When a Major Use Permit authorizes more than one large wind turbine, all of the large wind turbines subject to the Major Use Permit shall be uniform in color and tower and turbine design (pole, nacelle, etc.). In addition if there are existing large wind turbines on a lot that abuts the lot on which proposed large wind turbines would be located, the color and tower and turbine design of the proposed large wind turbines shall be uniform with that of the existing large wind turbines. Tower and turbine design does not include turbine height which may vary.

m. Property Maintenance. Except for periods of maintenance the property on which a large turbine is located shall be kept clean of turbine parts and or debris associated with the turbine operation.

(Added by Ord. No. 10262 (N.S.) adopted 5-15-13. Formerly 6951)
(Amended by Ord. No. 10359 (N.S.) adopted 10-29-14)

6954 SOLAR ENERGY SYSTEM

a. Solar Energy System, Onsite Use shall be permitted as follows:

1. A photovoltaic solar energy system for onsite use shall be allowed as an accessory use to all Agricultural, Civic, Commercial, Industrial and Residential use types in all zones in accordance with the following requirements:

i. Setback. A System shall meet all of the main building setback requirements of the zone or comply with Section 4835.f.

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ii. Height. A System shall meet the height limit of the height designator of the zone, except when allowed to extend not more than 5 feet above the highest point of the roof, in accordance with Section 4620.i.

iii. Solar Panel Description. The panel manufacturer and model shall be specified as part of the building permit.

iv. Special Area Regulations: Photovoltaic solar energy systems for onsite use subject to a Special Area Designator must comply with the applicable Special Area Regulations provisions of Sections 5000 through 5999.

b. Solar Energy System, Offsite Use shall be permitted as follows:

1. A photovoltaic solar energy system for offsite use with a project area of less than 10 acres shall be allowed with an Administrative Permit in all zones in accordance with the Administrative Permit Procedure commencing at Section 7050. The following findings must be made prior to approval of an Administrative Permit:

(a.) That the location, size, design, and operating characteristics of the proposed use will be compatible with adjacent uses, residents, buildings, or structures, with consideration given to:

i. Harmony in scale, bulk, coverage and density;

ii. The availability of public facilities, services and utilities;

iii. The harmful effect, if any, upon desirable neighborhood character;

iv. The generation of traffic and the capacity and physical character of surrounding streets;

v. The suitability of the site for the type and intensity of use or development which is proposed; and to

vi. Any other relevant impact of the proposed use; and

(b.) That the impacts, as described in paragraph "b.1.(a.)" of this section, and the location of the proposed use will be consistent with the San Diego County General Plan; and

(c.) That the requirements of the California Environmental Quality Act have been complied with; and

(d.) That the applicant has provided the County with an owner consent letter demonstrating to the satisfaction of the Director that the operator of the Solar Energy System is authorized to use the property for a Solar Energy System, unless the operator owns the land upon which the Solar Energy System will be located.

2. A photovoltaic solar energy system for offsite use with a project area of 10 acres or more, or a combination of parcels with a combined area of 10 acres or more is a Major Impact Service and Utility in all zones and shall require a Major Use Permit permitted in accordance with the use permit procedure commencing at section 7350. The use permit conditions shall include the requirements in subsection b.1(d) and subsection 3(a) through (d).

3. All other types of a solar energy systems or solar power plants including concentrating solar power plants, parabolic troughs, concentrating linear fresnel reflectors, stirling solar dish, or a solar power tower are a Major Impact Service and Utility in all zones and shall require approval of a Major Use Permit in accordance with section 7350 and the following requirements on any parcel of land:

   (a.) Setback. A system or plant shall meet all of the setback requirements of the zone.

   (b.) Height. A system or plant of more than 200 feet in height is required to comply with Federal Aviation Administration safety height requirements.

   (c.) Visual. The following measures shall be followed in order to minimize the visual impact of the project:

      i. Removal of existing vegetation shall be minimized.

      ii. Internal roads shall be graded for minimal size and disruption.

      iii. Any accessory buildings shall be painted or otherwise visually treated to blend with the surroundings.

      iv. A structure shall be non-reflective in all areas possible to blend with the surroundings.

   (d.) Security. The operator shall provide a security in the form and amount determined by the Director to ensure removal of the Solar Energy System. The security shall be provided to PDS prior to building permit issuance. Once the Solar Energy System has been removed from the property pursuant to a demolition permit to the satisfaction of the Director, the security may be released to the operator of the Solar Energy System.

4. Special Area Regulations: Photovoltaic solar energy systems for offsite use subject to a Special Area Designator must comply with the applicable Special Area Regulations provisions of Sections 5000 through 5999.

(Added by Ord. No. 10072 (N.S.), adopted 9-15-10)
(Amended by Ord. No. 10359 (N.S.) adopted 10-29-14)